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GEOLOGICAL SURVEY OF CANADA.

ALFRED R. C. SELWYN, F.R.S., F.G.S., DIRECTOR.

REPORT OF PROGRESS

FOR

1874-75.

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GEOLOGICAL SURVEY OF CANADA.

REPORTS

OF

EXPLORATION AND SURVEYS.

1874-5.

GEOLOGICAL SURVEY OF CANADA.

MONTREAL, *May*, 1875.

SIR,—I have the honor to transmit, for the information of His Excellency the Governor-General in Council, the accompanying Reports relating to the Surveys and Investigations of the Geological Corps during the season of 1874–75.

I have the honor to be,
Sir,
Your obedient servant,
ALFRED R. C. SELWYN.
Director of the Geological Survey.

To
The Honorable DAVID LAIRD, M.P.,
Minister of the Interior,
OTTAWA.

GEOLOGICAL SURVEY OF CANADA.

ALFRED R. C. SELWYN, F.R.S., F.G.S., DIRECTOR.

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1. Section of Bore-hole at McKenzie's Farm, Rat Creek, Manitoba. Mr. Selwyn's Summary Report.

2. View at Point Wilkins, Dawson Bay, Lake Winnipegosis; showing the result of the washing away of the marls underlying the limestones. Mr. Spencer's Report, page 67.

3. Map showing the Distribution of the Iron Ores of Carleton County, New Brunswick; to illustrate Mr. Ell's Report.

4. Section across the Township of North Burgess, Ontario. Mr. Vennor's Report. page 111.

5. Generalized Section across the Township of Bedford, Ontario. Mr. Vennor's Report, page 111.

6. Map of Lanark County, and parts of Renfrew and Leeds, Ontario; to illustrate Mr. Vennor's Report.

7. Tabular View of the Equivalency of the Seams in the Sydney Coal Field; to illustrate Mr. Robb's Report.

8. Drawing of *Sigillaria Sydnensis* from the roof of the slope at the Emery Mine' Cape Breton. Mr. Robb's Report, facing page 196.

9. Map of the Cape Dauphin District, Cape Breton, Nova Scotia; to illustrate Mr. Robb's Report.

10. Map of the Sydney Coal Field, Cape Breton, Nova Scotia; to illustrate Mr. Robb's Report.

11. Table of Sections of the Measures in the Sydney Coal Field, Cape Breton, Nova Scotia; to illustrate Mr. Robb's Report.

12. Drawing of Twin Crystal of Pyrrhotite from Elizabethtown, Ontario. Dr. Harrington's Report. Facing page 306.

NOTE.—The Map of Frontenac County, referred to on pages 106 and 113, has not been published, as further surveys are required to render it complete. It may, however, be consulted at the Survey Office.

ERRATA.

Page 71 Line 5 from top, *for* 4th *read* 14th.

76 Lines 2 and 3 from bottom, *for* cave *read* cove.

77 Line 7 from top, *omit* in both directions.

92 Line 12 from top, *for* Georgetown *read* Gagetown.

101 Line 10 from top; the conglomerate spoken of as Lower Carboniferous has since been found to be Devonian.

102 Line 15 from top, *for* crosses *read* crossing.

122 Line 6 from top, *for* below *read* above.

140 Line 18 from top, *for* four *read* two.

194 Line 6 from top. In the estimate of the quantity of coal in the Lingan tract, no allowance has been made for partings of clay or shale. For the thickness of these, see sections on pages 192 and 193.

204 The paragraph from line 14 to line 19 inclusive should be transferred to page 199, and follow directly after line 21 from the top.

221 *Omit* "FEET. IN." placed over the figures in the analyses. The figures are correct, and simply require decimal points between the columns.

295 Lines 2 and 4, *for* S. *read* T. and V. respectively.

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SUMMARY REPORT

OF

GEOLOGICAL INVESTIGATIONS,

BY

ALFRED R. C. SELWYN, F.R.S., F.G.S.

ADDRESSED TO

THE HONORABLE DAVID LAIRD, M. P.

MINISTER OF THE INTERIOR.

Progress during the past year.

Distribution of explorers.

SIR,—I have the honor to submit for your consideration the customary annual summary statement of the progress which has been made, under my direction, in the Geological Exploration of the Dominion. Also, a statement of the work which has been done in the Geological Survey Laboratory, and in the Museum, in connection with its improvement and extension, and with a view to augment its usefulness and popularity. With these are also submitted reports from those associated with me in the work, which, as will be observed, has embraced investigations in Nova Scotia and Cape Breton Island, as well as in the Provinces of New Brunswick, Quebec, Ontario, Manitoba, and British Columbia, the distribution of the Geological Explorers in these several Provinces having been as under:

British Columbia	James Richardson.
North-West Territory and Manitoba	R. Bell, J. W. Spencer, and two drilling parties.
Ontario	Henry G. Vennor.
Quebec	H. Y. L. Brown and Arthur Webster.
New Brunswick	Robert Ells.
Nova Scotia and	W. McOuat and Scott Barlow.
Island of Cape Breton	C. Robb and H. Fletcher.

In the distribution of the staff, as above stated, it may, perhaps, be thought that an undue share of attention was being devoted to investigations in Nova Scotia, to the neglect of that of other extended and less known portions of the Dominion. In making this distribution, however, I have been influenced by the recognition of the fact that the development of coal and iron mines exerts a far greater and more enduring beneficial influence upon the material progress and prosperity of the country than can be ascribed to that of any other product of mining industry, and therefore I deemed it to be one of the first duties of the Geological corps that it should endeavour to produce as quickly as possible complete and reliable maps and reports of these most important resources of the Dominion. This view was likewise held by my predecessor, Sir W. E. Logan, who, together with the late Mr. Edward Hartley, commenced in 1868, and in the following year completed a detailed and elaborate Map and Report of the Picton and New Glasgow coal-field,* while in his Summary Report, dated 1st May, 1869, he writes: "The true structure of a coal-field in which valuable seams of fuel exist being a matter of great commercial importance, no pains should be spared in making it out, but where, as in the present instance, it is of a complicated character, while natural exposures and crop workings are few, it will require much time to accumulate the number of facts required to arrive at a satisfactory conclusion."

nportance of oal and iron ines.

The force of the latter part of this remark can only be fully appreciated by the working geologist; but I may say that in the continuous progress of the examination since then, it has been found to be very generally applicable to the Nova Scotia coal-fields, and has been the true cause of what might seem in the absence of any such explanation, to be an unnecessary delay in the working out and in the publication of the results of the survey. In the meantime, however, as a practical result of the work in advance of publication, we have been enabled already to afford to persons actively engaged in endeavours to develope the working capabilities of the coal-fields a very considerable amount of valuable advice and information, and especially so in the preventing large expenditures in searching for seams of coal where the geological structure precludes the possibility of their being found.

nformation fforded.

Besides the several geological exploring parties above-mentioned, two boring parties have been employed during the past season in the North-West Territory, with a view to ascertain where the eastern limit of the Cretaceous coal bearing rocks is, and at the same time whether artesian wells affording good water can be made

oring in the orth-West.

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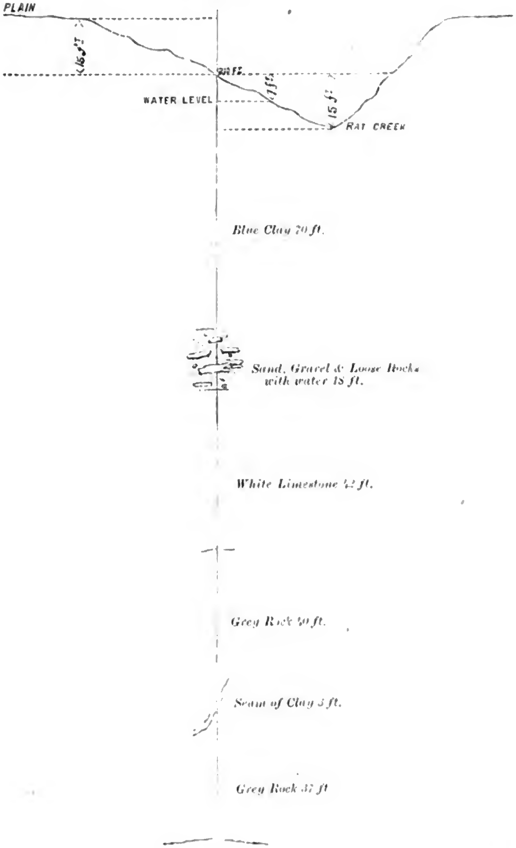
* Published in the Report of Progress 1869–70.

LIBRARY
OF THE
UNIVERSITY
OF
CALIFORNIA

SECTION OF BORE HOLE
at
McKenzie's Farm, Rat Creek,
MANITOBA,
66 Miles West of Fort Garry.
1874.



Scale 40 ft. to an Inch.

upon the prairies where surface water is either very scarce, or for the most part too saline for domestic purposes. The localities where these operations were carried out are at Rat Creek,* and in the vicinity of Fort Ellice, on the Assineboine; and on Swan River, near Fort Pelly. As the details of the work have already been submitted, it does not need to be further alluded to on this occasion, except to state that the results have not been as complete and satisfactory as might have been anticipated; but, so far as they have gone, they lead to the conclusion that no difficulty will be found in obtaining a good supply of water on any part of the western plains at a moderate depth beneath the surface. A sufficient depth has not yet been reached, either at Fort Ellice or at Fort Pelly, to prove the coal bearing strata. At Rat Creek, however, the superficial deposits were penetrated at 88 feet, and the underlying rock bored through to a depth of 122 feet, the section being as shewn in the accompanying woodcut.

Water supply on the plains.

The cream-coloured limestone shewn in the section is certainly either of Devonian or Silurian age, probably the former, and it does not differ from the rock of that age, where it comes to the surface, with a slight westerly dip, around Winnepegosis and Cedar Lakes. The dark grey fine-grained rock beneath the limestone is unlike any rock, that has so far as I am aware, been observed cropping out in this region. It may, however, not improbably be a part of the same ridge of metamorphic and gneissoid rocks with quartz veins, noticed in 1858 by Professor Hind, at St. Martin's Lake, and which are probably either of Laurentian or Huronian age. In any case, the finding these rocks at Rat Creek, together with other ascertained facts in connection with the distribution of the different formations, prove that neither coal or lignite beds are at all likely to occur beneath any portion of the level country which constitutes the first prairie steppe.

Age of rocks bored through.

Coal or lignite not likely to be found on first prairie steppe.

The position of the bore-hole at Rat Creek is about half way down the slope from the level of the plain to the creek bed, a total height of about thirty feet, and as the water rises to within seven feet of the surface, it is not unlikely that a cut made to intersect the hole at a somewhat lower level would result in establishing a permanently flowing spring, which would be a very great boon to the settlers in the vicinity.

Situation for a permanent flowing spring.

As instances of what has recently been accomplished in other countries, in deep boring, and also as shewing the cost, and the time required for such work, the following particulars are here given:

Deep boring in other countries.

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* Rat Creek is 66 miles west of Fort Garry, on the first or lowest prairie steppe.

Sperenberg.

1st. The deep boring made by the Prussian Government engineers at Sperenberg, 25 miles south of Berlin, the depth reached was 4,172 feet, the greatest yet reached in the earth's crust. The first 984 feet was made by manual labour at a cost of £1,600 stg., $8,000. Steam power was afterwards used, and the total cost was £8,717 14s. 0d. stg., $43,588 50. The actual working time being 3 years, 10 months and 15 days. The hole was commenced with a diameter of 15 inches, and at 956 feet had been reduced to 12½ inches, being lined with tubes from the surface. How much the hole diminished in diameter below 984 feet is not stated. Percussion borers, with rods, were employed.

Missouri.

2nd. The boring at the Insane Asylum, St. Louis, Missouri, depth 3,837 feet, commenced at six inches diameter, in a well seventy feet deep, in March, 1866, and finished 9th of August, 1869. Steam power, percussion borers, and wooden (white oak) rods in 33⅓ feet lengths. Total cost, less the value of the Plant, $69,000.

Bohemia.

3rd. "Broad Bore Hole" Bohemia; depth 2,001 feet; commenced 15th July, 1874, and completed to the depth named, 8th of January, 1875; cost not stated. English Diamond Drill.

Sussex, England.

4th. Sub-wealden Exploration, Sussex, England, depth 1,018 feet, commenced late in 1872; completed in June, 1874. Total cost not stated, but the Diamond Drill Company offered to bore 200 feet further at the rate of £2 stg. per foot, a price considerably under their rate for boring at such a depth, but made in consideration of this boring being a purely scientific undertaking. It is now proposed to carry this boring to a depth of 2,000 feet, but it will have to be commenced again from the surface.

Most successful bore-holes begun with large diameter.

It may be remarked that the most successful, and in the end the least costly, borings have invariably been those which have been commenced with a large diameter, or from six up to as much as fifteen inches. This arises from the greater facility afforded for inserting any tubing that may be required, and also from the lessened liability of the rods to come in contact with the sides of the hole and to break off fragments which fall down, and often, when the hole is small, jam and break the rods, causing so much trouble and delay as not unfrequently, to make it cheaper to abandon the hole and commence afresh from the surface.

Geological Corps too small for the area requiring examination.

Adverting to the statement on page 1 of the distribution of the Geological Corps during the past season, and, looking to its numerical strength as there given, it must, I think, be admitted to be entirely disproportioned to the immense area requiring examination, and over which its labours now have to be extended. To indicate this more

Comparison with the British Survey.

forcibly, and at the same time to suggest the desirability of organizing the field staff of the Dominion Geological Survey on a somewhat more adequate basis, it may be well to compare it with the British Geological Survey, which has now been in progress since 1834, but, unlike the Canadian Survey, has never been compelled to devote any part of its resources to making topographical measurements for the construction of the essential preliminary maps. Here, this work unavoidably occupies fully two-thirds of the time and attention of the explorers, and constitutes one of the largest items in the expenditure of the Survey.

The total area of the United Kingdom is 121,000 square miles, and the field staff of its Geological Survey numbers *sixty-four* members; namely:

1 Director General.
3 Local Directors; 1 in England, 1 in Scotland, 1 in Ireland.
4 District Geologists.
14 Geologists, and 42 Assistant Geologists.

The Director General is also Director of the Geological Museum and the School of Mines, for which, I believe, he receives a special salary.

The precise extent of the Dominion in square miles, I am not able to state, but if we assume it to be twenty times larger than the United Kingdom; or, 2,420,000 square miles, we shall certainly be within the mark. The geological examination of the whole of this immense area, extending from the Atlantic to the Pacific, is now committed to a field staff, which numbers only *eleven* members; namely:

1 Director.
10 Geological Explorers.

Annual appropriation for the Canadian Survey.

Appropriations in the United States.

The total annual appropriation for carrying on the survey (including boring operations), and for the payment of all expenses (rent, repairs, fuel, light, water, insurance, &c.) connected with the maintenance of the Geological Museum, Laboratory, Library and Offices in Montreal, as well as for the engraving, printing and publishing of all maps, sections, illustrations and reports—the latter in English and in French—is $45,000.00. This is a sum not greater than is granted for similar purposes by many single States in the neighboring Union; is very much less than is annually appropriated by the Federal Government for the United States Geological Survey of the Territories under Dr. F. V. Hayden, and amounts to only a fraction more than one cent per head of the present population of the Dominion.* Under these circumstances I may be permitted to express a hope that when the appropriation for geological purposes is again under the consideration of the Government, it will, through the enlightened liberality of the Ministry, and of Parliament, be largely augmented, so that the Survey and the Geological Museum can be organized on a scale more nearly in accordance with the extent, and with the rapidly increasing wealth and importance of the country.

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* An appropriation of $75,000.00 has been made for the survey of the season of 1873, of the Territory of Colorado alone, (See Dr. Hayden's Report, page 1, 1873.) Each party surveyed an area of about 5,000 square miles.

Topographical work.

In reference to the topographical work of the Survey already alluded to, I may state that, during the past summer, not less than 2,000 miles have been measured, either by chain, odometer, micrometer, or pacing, and the bearings taken either with transit, sextant, or prismatic compass; while the track surveys on which the distances have only been estimated, amount to several hundred miles more. And the total distance travelled by the explorers while at work, and going and returning, may be roughly stated at 60,000 miles as shewn by their respective diaries. In future, the travelling charges of the Survey will be considerably increased, owing to the withdrawal of free passes over the Grand Trunk Railway, a privilege which has, till this year, been invariably accorded to all the principal members of the staff.

Distance travelled

Maps.

In the summary reports, and in the special reports of previous years, several maps have been mentioned as being in preparation.

1st. A map of the Eastern Townships on a scale of four miles to one inch, engraved in four sheets, and embracing an area of 26,121 square miles, from St. Jerome and the Lake of the Two Mountains on the west, to ten miles east of St. Thomas, below Quebec, and from the U.S. Boundary along the 45th parallel of latitude, to eight miles north of Three Rivers, or to the parallel of 47° 50′.

2nd. A map on a scale of one inch to the mile of the Spring Hill, and a portion of the Joggin's coal-fields in the County of Cumberland, Nova Scotia, embracing an area of about 272 square miles.

3rd. A map on a scale of four miles to one inch of the Grand Lake and Clones' coal-fields in Queen and Sunbury Counties, New Brunswick, and embracing the whole area of these counties.

4th. A map of the Sydney coal-field, Cape Breton, on a scale of one mile to an inch, covering an area of 250 square miles. The additional topographical measurements which were required for the construction of these maps have been completed during the past summer, but before the geological structure can be correctly delineated upon them, some further investigations are required. When this work has been completed, it is proposed to publish these maps geologically colored, to illustrate the reports on the districts to which they refer. Meanwhile, however, in pursuance of the instructions conveyed to me in your letter of the 23rd January, 1874, arrangements have been made, by which Messrs. Walker and Miles will use them for their Dominion Atlas now printing, and in which, with the exception of the Cape Breton map, they will accordingly appear, but without geological coloring, and, though in this respect imperfect, their early publication will at once render available, a very considerable amount of original and really valuable topographical information for the most part derived from the labours of the Geological Corps, but including also other unpublished surveys from various sources. Sir W. E. Logan's large map of Canada and the adjacent states, on a scale of 25 miles to one inch, will likewise appear in the Dominion Atlas geologically colored, and for this purpose the publishers have been supplied with transfer copies taken in London from the plates, and transmitted to them in New York.

Arrangements with Messrs. Walker & Miles.

In my report of last year's operations it is stated, page 8, that a sketch map had been made of the Saskatchewan River, from Rocky Mountain House to Cumberland Lake, and that a reduction of it had been prepared to accompany that report. This reduction, drawn by Mr. R. Barlow, to a scale of sixteen miles to one inch was, however, not completed in time to be issued with the report, but is now available, having been printed at the establishment of the Photo-Lithographic Company in New York. The impressions are distinct and sharp, and quite equal, if not superior to maps produced by the usual lithographic process, with the advantage of costing less and being more quickly executed.*

Sketch map of the Saskatchewan.

The greater part of my own time during the past summer has been occupied in attending to matters connected with the general work of the Survey and the Museum. Early in July, a few days were spent in company with Sir W. E. Logan, in investigations connected with the determination of the relative antiquity of the crystalline and the fossiliferous rocks in the Eastern Townships, alluded to in my last summary report, page 2, and with a view of further studying the aspect and relations of these rocks in their north-eastern extension, I proceeded to Rimouski on the Lower St. Lawrence, and thence *via* Metis and the line of the Intercolonial Railroad to Newcastle, New Brunswick.

Mr. Selwyn's labors.

Rimouski to Newcastle, N. B

All the principal exposures and rock cuttings on the route were carefully examined. In some of these, especially at Metis, and near the summit level between the St. Lawrence and the Restigouche, the remarkable foldings and plications which have affected the strata, as well as the mineral characters of the different groups, can be well studied. I failed, however, to find evidence of the existence anywhere in this region of rocks clearly older than the Primordial Silurian (Cambrian) and the Quebec group; while a large part of it is certainly occupied by rocks of Upper Silurian and Devonian age.

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* I have to thank the Surveyor-General, Lieut.-Col, Dennis, for suggesting this mode of printing, and also for kindly transmitting the manuscript to New York.

Primordial Silurian and Quebec group.

Coal-fields of Cumberland County, N. S.

Leaving Newcastle on the 28th of July, I proceeded to Spring Hill, in Cumberland County, Nova Scotia, where, in company with Messrs. Scott, Barlow and McOuat, some obscure points affecting the structure of this coal-field were investigated, resulting in the determination of the approximate position and course of several large and important faults. The limit of the Productive Coal Measures in the Spring Hill and Joggin's coal-fields can now be very closely laid down, which in future will be the means of preventing much waste of time and money in boring and sinking for coal seams in situations where there is no possibility of finding them.

Reported deposit of hematite in Prince Edward Island.

A report having been received that an extensive and valuable deposit of hematite had been discovered in Prince Edward Island, and the statement being supported by some small samples of excellent ore which were said to have been taken from the vein, I thought it desirable to visit the locality, which I accordingly did in August, but only to find that no such deposit existed as had been represented, and that the samples exhibited, instead of having been taken from the vein, had been picked up on the shore at Gallas Point, where it had already been described by Principal Dawson, as follows:—"Red Hematite: an excellent ore of iron "in concretions at Gallas Point and elsewhere. At Gallas Point sufficient "quantities may be picked up on the beach to afford a small additional "supply to an iron furnace, but not to warrant any independent enter-"prise."*

My impression is, that even with this limited application of it, the ore would very soon be exhausted.

Sydney coal-field.

From Prince Edward Island I went to Sydney, Cape Breton, and spent some days with Mr. Charles Robb, studying the structural details of the Sydney coal-field, and the relations of the coal measures to the underlying Mill-stone Grit and Lower Carboniferous formation. An examination was also commenced between Sydney and Louisburg, with a view of gaining some definite information respecting the lower palæozoic rocks of Cape

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* Report on the Geological Structure and Mineral Resources of Prince Edward Island, by J. W. Dawson, LL.D., F.R.S., F.G.S., 1871. Printed by authority of the Government of Prince Edward Island.

Lower palæozoic rocks of Cape Breton.

Breton, and it was intended to extend this examination into that almost wholly unexplored region embraced in the Counties of Victoria and Inverness. The work was, however, unavoidably suspended after the lapse of only a few days, but nevertheless some very interesting facts were observed, shewing the occurence in Cape Breton of a thick series of strata, very closely resembling in mineral and physical characteristics, and probably also corresponding in age and origin with the great Lower Silurian volcanic accumulations which constitute the principal mountain masses of North Wales—Snowdon, Cader Idris, etc.

Should further investigation of this interesting series of rocks prove this view to be correct, then the great gap that apparently existed in the Nova Scotian lower palæozoic series, between the highly fossiliferous and characteristic Upper Silurian rocks of Arisaig and the Primordial Silurian or Cambrian slates and quartzites of the gold mining districts, may be satisfactorily filled up, and the complete series of formations be recognised in Nova Scotia, as it occurs in "Siluria" from Lower Cambrian to Ludlow inclusive. Dr. Honeyman in his remarks on the crystalline rocks of Arisaig and George's River,* has already suggested the probability of these being of Lower Silurian age, and has paralleled them with the somewhat similar crystalline rocks of the Quebec group in Eastern Canada, though as yet no fossiliferous beds have been found associated with them, either at Arisaig, or at George's River.

The examinations recently made by Mr. Robb at Kelly Cove on the Great Bras D'Or Lake show that a similar series of crystalline rocks,—magnesian limestones, serpentine,† &c.,—occur there between the Carboniferous series and the great mass of syenite, which has been supposed to be of Laurentian age; but which will, I think, more probably prove to be an *intrusive* mass nearly corresponding in age with the great central granitic axis of Nova Scotia, which is undoubtedly pre-Carboniferous and post-Devonian.

Age of rocks at Wentworth, on the Intercolonial Railroad.

As regards the occurrence of Lower Silurian rocks in the cutting at the Wentworth station of the Intercolonial Railroad, as stated by Dr. Honeyman, I may say that in 1873, Mr. McOuat, of the Geological Corps, collected 300 specimens from this locality. Mr. Billings has examined this collection and informs me that, though the specimens are not of such a character as to enable him to express a decided opinion upon their age, yet that the evidence they afford is, on the whole, against their being older than Middle Silurian, or about the age of the Clinton group.

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* Proceedings and transactions of the Nova Scotian Institute of Natural Science, vol. III, part IV.

† Further particulars are given of these so-called serpentines in Dr. Harrington's Report.

The following are the only species Mr. Billings has been able to determine:—*Graptolithus*, allied to *G. Clintonensis*; *Lingula oblonga*; *Leptæna transversalis*; *Strophomena corrugata*; *Rhynconella Eva*, and *Atrypa reticularis*.

The matrix is a somewhat hardened, dark blue, rubbly shale, precisely similar to the blue Ludlow shales of Britain.

Mr. Billings' labours.

In the early part of the year Mr. Billings was chiefly occupied in attending to the printing of Part I. of the second volume of the Palæozoic Fossils of Canada, which was issued in August last. And he has since been engaged upon Part II. of the same volume, which he hopes will be completed and published during the present year.

His duties as Curator of the palæontological branch of the Museum, and the examination of collections brought in by the field parties, have also occupied a portion of his time.

Improvements in the arrangement of specimens in the Museum.

A good many improvements have been made in the arrangement of the specimens exhibited in the Museum, especially in making them more generally interesting and instructive, by the addition of printed labels giving a brief descriptive notice of the specimen and the meaning of its name. Thus we find *Protichnites* and *Climactichnites*—names which probably to the majority of persons visiting the Museum are perfectly meaningless—described as follows:

Tracks or Trails of Marine Animals. *Protichnites*, or "First Fossil Foot-prints." These consist of two rows of small impressions, with a groove between them. The groove is supposed to have been made by the tail. No portion of the body of the animal has ever been found. It is supposed, however, to have resembled the King Crab or *Limulus* of the present day.

The tracks occur in the Potsdam Sandstone in several localities, but most abundantly near Beauharnois, about 20 miles from Montreal. There are six kinds of tracks which have been named by Professor Owen as follows:

Protichnites septem-notatus.
" *octo-notatus.*
" *latus.*
" *multi-notatus.*
" *lineatus.*
" *alternans.*

All of these are on exhibition in this Museum.

Attention was first directed to these tracks by the late Mr. Abraham, who published an account of them in the *Montreal Gazette*, and brought them under the notice of Sir W. E. Logan. They were described in the Quarterly Journal of the Geological Society in 1852.

The smooth part of the stone is supposed to have been ground down and partly polished by the action of drifting ice. The remainder exhibits a fine display of ripple-marks. The small specimen in the upper right hand corner shows the effect of either the wind or the current upon the sand.

Additions to the palæontological collection.

The following additions to the collection have been received during the year:—

1. Collected by J. Petet, Devonian fossils, Ontario	3,000	specimens.
2. Presented by Major Grant of Hamilton, Clinton and Niagara fossils	85	“
3. Collected by T. C. Weston, Quebec Group fossils, Temiscouata Lake	150	“
4. Presented by the Revd. Mr. Petitot—Pipeclay, with impressions of leaves from Mackenzie River, above the mouth of Great Bear Lake River	2	“
Corals from Mackenzie River, below Fort Norman	3	“
Atrypa reticularis, from the Rocky Mountains, near Fort Good Hope	4	“
Atrypa reticularis and *Cyrtina* from the Rocky Mountains, near Fort Good Hope. (These are certainly Devonian, and are beautifully preserved specimens.)	2	“
Fossil wood from Mackenzie River, below Great Bear Lake River.	3	“
5. Collected by T. C. Weston, fossils from the Guelph formation, Ontario	571	“
6. Purchased from C. DeCew, Devonian fossils from Ontario	1,833	“
7. Purchased from J. W. Tayler, fossils from Gamoche Bay, Anticosti, Middle Silurian	250	“
8. Purchased from C. DeCew, Devonian fossils from Ontario	1,500	“
9. Collected by James Richardson, fossils from the Cretaceous rocks of British Columbia	350	“
10. Collected by J. W. Spencer, Devonian and Cretaceous fossils from Manitoba		
11. Collected by A. R. C. Selwyn, Middle and Upper Silurian fossils from the Restigouche River Valley	25	“

Fossils examined by Principal Dawson.

The fossil leaf impressions above mentioned, have been submitted to Principal Dawson; among them he finds the following genera and species:

1. Populus Richardsonii.—*Herr.*
2. Corylus, Macquarriei, *hazel.*
3. Sequoia Langsdorffii.
4. Corylus, sp.
5. Leaf like Diospyros, *date.*

The fossil woods from Mackenzie River have been sliced by Mr. Weston for examination under the microscope, and Principal Dawson, who has kindly examined them, states that they represent three distinct species; one of the pine type and two of the cypress type.

Services of Mr. Whiteaves secured.

As none of the specimens in Mr. Richardson's large and very interesting collection of Cretaceous and other secondary fossils from the coal-bearing rocks of Vancouver and other Islands in the Strait of Georgia, and from the Queen Charlotte group, had then been examined, I last year secured the services of Mr. J. F. Whiteaves, F.G.S., for this work, and the first result of his investigation is given on pages 260–268, of the Volume of Reports for 1873-74, recently published.

Note by Mr. Whiteaves on fossils from the Queen Charlotte Islands.

Mr. Whiteaves has since been occupied in a careful study of the valuable and unique collection of the fossils from the coal-bearing rocks of the Queen Charlotte Islands, which were visited by Mr. Richardson in 1872. Of this collection, Mr. Whiteaves says: "These fossils have a double interest; first, as exhibiting a blending of Jurassic and Cretaceous types, a circumstance before without parallel in North America; and secondly, as tending to elucidate the geology of a part of the world never before examined by a competent observer. There are forty species in the collection; one of which is a coral, two are brachiopods, sixteen lamellibranchiate bivalves, five gasteropoda, and sixteen cephalopoda."

A detailed description of the various species, with illustrations, is being prepared, and it is hoped will be ready for publication during the ensuing summer.

Cretaceous fossils from Sucia Island.

In November last, Mr. Richardson returned from the Pacific Coast, bringing another valuable addition to the collections, consisting of a very beautiful series of Cretaceous fossils from Sucia Island. These have likewise been carefully examined by Mr. Whiteaves, who states that there are about forty species of which he believes about one-third to be new to science. Those which can be referred to species already described, have been named and mounted for exhibition in the Museum; and a report on the whole, with figures and descriptions, is in course of preparation.

Large collection of Secondary fossils.

Need of funds for cases.

The Geological Survey Museum now possesses by far the largest collection in existence of the Secondary fossils of the British American Pacific Coast, obtained from a number of localities between the forty-ninth and the fifty-fourth parallels of latitude; and it is much to be regretted that want of funds to provide the requisite fittings and cases in the Museum, will at present prevent their being exhibited.

Besides geological collections—rocks, minerals and fossils—Mr. Rich-

Plants and marine animals from British Columbia.

ardson has brought a number of specimens of plants and of marine animals which will be placed in the Museum of the Natural History Society. Among the latter may be mentioned, four fine and perfect specimens, taken alive, in about 50-fathom water, of the gigantic Sea-Pen, "*Verillea Blakei*," the largest of which is nearly eight feet in length. Also, a fine specimen of the large edible crab of the West Coast, "*Echidnocerus cibarius*" (White), and three rare species of fishes. Mr. Whiteaves states that several of the hydroids, polyzoa and crustaceans in the collection are, as far as he can ascertain, undescribed species. It is proposed to publish a paper on these and on the other marine animals, and also one on the plants, in an early number of the "Canadian Naturalist."

Investigations in the chemical laboratory.

The investigations made in the laboratory by Dr. Harrington and Mr. Hoffmann have been of the same varied character as in previous years.

Three complete analyses, six partial analyses, and five assays of iron ores have been made. The results of some of these were published in the Report of Progress for 1873-74. The analysis of a clay iron-stone, brought by Mr. Bell from the "Dirt Hills," and mentioned in his report, page 78, Report of Progress, 1873-74, shews it to be a rich and valuable ore, and one which, if the quantity prove sufficient, may eventually be of very considerable importance.

Analyses of coal from the Styles Mine, N. S.

Proximate analyses have been made of seven specimens of lignite and eight of bituminous coal. Most of these were published in Appendices to the Reports of 1873-74. The results of the analyses of two samples brought by Mr. Scott Barlow from the "top bench" of the Styles Mine, Nova Scotia, not previously given, are as follows:

	I.		II.	
	Slow Coking.	Fast Coking.	Slow Coking.	Fast Coking.
Water (loss at 115° C.)........	4.05	4.05	3.72	3.72
Volatile combustible matter....	33.72	38.18	33.24	37.66
Fixed Carbon................	55.83	51.37	52.15	47.73
Ash (purplish-grey)...........	6.40	6.40	10.89	10.89
	100.00	100.00	100.00	100.00

The specimens presented a curious *slickensided* appearance, the lustre was dull and somewhat resinous, and the fracture irregular. Both of them contained a good deal of pyrites, and a little graphite occurred in joints in No. II. By rapid heating a bright and tolerably firm coke was obtained.

Various assays and analyses.

Six assays have been made for silver, lead, copper, nickel and cobalt; and complete analyses of six minerals and rocks of scientific interest, as well as partial analyses of nine others. Among the minerals may be mentioned a specimen of iron pyrites from Londonderry, Nova Scotia, which Mr. Hoffmann found to contain 0.144 per cent. of nickel, and 0.813 per cent. of cobalt. In what quantity the pyrites occurs, is not at present known. For the particulars of the commercial value of such cobaltiferous ore, I may refer to pages 750 and 751 of the Geology of Canada, 1863, where it is shewn that ores containing only from 0.5 to 0.6 per cent. of oxyd of cobalt can be very profitably worked.

Among the rocks analysed was a magnesitic ophiolite from Melbourne, in the Eastern Townships, which was found to contain chromium, manganese, nickel and cobalt. Full details of this rock will be given in a future report.

Mr. Hoffmann has made some complete and interesting analyses of iron slag from the Acadia Iron Company's blast furnace, and also of the crushed quartz used for making the furnace hearths, and of the bar iron.

Microscopic study of rocks, and work in the Museum.

In addition to the laboratory work, the microscopic study of a number of crystalline rocks has engaged the attention of Dr. Harrington. He has also devoted considerable time to perfecting and arranging the collection of minerals and rocks on exhibition in the Museum, including the special collection of Canadian iron ores, alluded to in my last summary report, page 8, which is now nearly completed, and forms a very interesting series, illustrating the wide distribution of valuable iron ores in the Dominion.

Interesting mineral waters.

In February last, samples of two very interesting and remarkable mineral waters were sent by Dr. Grant of Ottawa to the Museum. These have been analysed qualitatively by Mr. Hoffmann. The one contains 26.2 of solid parts in 1,000, or 2.62 per cent.; and the other 2.50 per cent. The details of these analyses, and of other investigations in the laboratory, are given in Dr. Harrington's report.

As forming also a part of the investigations undertaken by the survey during the past year, I have to transmit an interesting and valuable report by Mr. J. Lionel Smith, on the History and Statistics of the trade and manufacture of salt in Canada. This report forms a useful and appropriate sequel to the reports by Dr. T. Sterry Hunt, published in the volumes of the Geological Survey Reports for 1866 and for 1869, in which the geological and chemical relations of the salt deposits and the various processes of manufacture are given in detail.

Report by Mr. J. Lionel Smith.

New offices.

During the past summer, the offices of the Survey were removed to the new building erected by Sir W. E. Logan, in St. James Street, immediately in the rear of the brick wing of the Museum, with which it has been connected by fire-proof iron doors.

The rooms thus vacated in the Museum building have become available, and some of them have already been fitted up for the exhibition of specimens; funds are, however, now wanting for the repairs, alterations and fittings, required before the other rooms can be similarly utilized.

Importance of a collection of mining and metallurgical models.

It is very desirable that there should be on exhibition in the Museum for reference and for general information, a good collection of models and examples of the newest and most improved mining machinery, tools and implements, as well as of metallurgical works and processes. Such a collection is a very important adjunct of every Museum of Economic Geology, and considering the proportions which the Museum and the associated Library of the Canadian Geological Survey have already attained, it is certainly a matter to be regretted that their full usefulness for practical and scientific purposes of reference and instruction, should be curtailed and hindered by any short-sighted parsimony, in granting the comparatively insignificant funds required for their proper and efficient maintenance and progress.

Repairs in the Museum.

The interior of the Museum building had not been painted or repaired for twenty years. During the past summer this much-needed work has been carried out so far as the resources of the Survey permitted, and a great improvement is now visible in the appearance of the Museum. The expenditure for these purposes—repairs, fittings, etc.; and for taking down, repairing and re-setting the steam boiler for heating the building, has amounted to over $2,000.00 during the year.

Number of visitors.

From the 1st of May, 1874, to the 1st April, 1875, 1,017 persons visited the Museum. This, though still a very small number, is a considerable increase over previous years, nothwithstanding that for several weeks during the past summer, while the repairs were in progress, the doors were necessarily closed. Next year I hope to have a full descriptive catalogue of all the specimens prepared. When this can be printed and made available for the public, the collection will become more generally interesting and instructive.

Descriptive catalogue.

Geological collections for schools.

In December last an application was received from the Board of School Trustees of Elora, Ontario, to be supplied with a geological collection for the use of the public school, and a set of typical Canadian rocks, minerals and fossils, comprising 277 specimens, properly named and catalogued, was prepared and sent to the Board, on the understanding that suitable cases for its preservation would be provided, and that it was to be exclusively the property of the public school.

On application, similar collections will be prepared for distribution among the managers of public schools, who can guarantee that they wish to utilize them for educational purposes, and are in a position to do so.

Mining statistics.

Efforts have been continued to obtain reliable annual statistics of mines and mineral produce in the Dominion, but the result has, I am sorry to say, not been encouraging. Out of 216 circulars issued to the various managers and proprietors of mines in all parts of the Dominion, only 65 have been returned with the information asked for. The apathy on the subject evinced by some, and the reluctance of others, to give any information, is certainly surprising. The general value and usefulness of such statistics does not need to be pointed out to any person of ordinary intelligence, and it is quite impossible that their publication can, in any way, injuriously affect individuals, and yet the fear of its doing so is, I imagine, the only way to account for the very limited response which our efforts have met with. They will not, however, be abandoned, and it is hoped that gradually more encouraging and satisfactory results will be attained.

Number of publications distributed.

From the 1st of July, 1873, to the 1st of April, 1875, 2,953 copies of the various maps, and other publications of the Survey, have been distributed.

Additions to the library.

Appended, is a list of the additions to the library during the same period by presentation and purchase. Also, a list of the scientific magazines and journals subscribed for and regularly received by the Survey.

I have the honor to be, Sir,
Your obedient servant,
ALFRED R. C. SELWYN.

Geological Survey Office,
MONTREAL, 1st May, 1875.

ADDITIONS TO THE LIBRARY,

1st JULY, 1873, to 1st APRIL, 1875.

BY PRESENTATION.

Royal Society of London :—

Transactions....................Volume 161, Part II.
" .... " 162, " I.
" .... " 163, " I-II.
" .... " 164, " I.
Proceedings................Volume XXII, No. 148-155.
" .... " XXIII, " 156-158.

The Literary and Philosophical Society of Manchester :—

Memoirs.....................Third Series, Volume XV.
Proceedings.......................Volume VIII-XII.

Manchester Geological Society :—

Transactions................Volume XIII, Part I-VIII.

Manchester Scientific Students' Association :—

Annual Report for the year 1873.

Royal Society of Edinburgh :—

Proceedings..............Volume VII, Sessions 1871-2.
" .... " VIII, " 1872-3.
Transactions.............Volume XXVII, Part 1, 1872-3.

Geological Society of Edinburgh :—

Transactions...................Volume I, Part I-II-III.
" .... " II, " I-II-III.

Botanical Society of Edinburgh :—

Transactions and Proceedings........Volume XI, Part I.

Geological Society of Glasgow :—

Transactions.................Volume I, Part I.
" .... " II, " I-II-III.
" .... " III, " I-II.
" .... " IV, " I-II.

On the Phenomena of the Glacial Drift of Scotland, extracted from the Transactions of the Geological Society of Glasgow, Vol. I, Part II; by A. Geikie, F.R.S.

Geological Survey of India.—Thomas Oldham, LL.D., Director:—

Memoirs.......................Volume VIII, Part I-II.
" .... " IX, " I-II.
" .... " X, " I.

Geological Society of India—continued:—

Records..............Volume V, Part I-II-III-IV, 1872.
" .... " VI, " I-II-III-IV, 1873.
Paleontologia Indica.............Volume IV, Part I-II.
" ....Series VIII, Part IV-V.
" .... " IX, " I-IV.

New Zealand Institute.—JAMES HECTOR, M.D., F.R.S.:—
Transactions and Proceedings, Volume VI, with 26 Plates.
Meteorological Report, 1873.
Museum and Laboratory Annual Report, 1872-3

Nova Scotian Institute of Natural Sciences:—
Proceedings and Transactions, 1872-3.

Geological Survey of Newfoundland.—ALEXANDER MURRAY, F.G.S., Director:—
Report of Progress, 1873.

Commissioners of Crown Lands of the Province of Ontario:—
Report, 1873.

Board of Agriculture, Ottawa:—
Census of Canada, 1870-1.

W. H. BAILY, F.L.S., F.G.S., Dublin:—
Figures of Characteristic British Fossils, with descriptive remarks, Part I-II-III.

DR. STERRY HUNT, LL.D., Boston:—
Chemical and Geological Essays, 1875.
Coal and Iron of Southern Ohio, &c.

United States Geological Survey of the Territories.—DR. F V. HAYDEN, U.S. Geologist:—
Fossil Vertebrates, Volume I; by PROF. JOSEPH LEIDY.
Synopsis of the Acrididæ of North America; by CYRUS THOMAS, PH.D.
Profiles Sections and Illustrations accompanying the Final Report of the Chief Geologist, 1872.
First, Second and Third Annual Reports of the United States Geological Survey of the Territories, for the years 1867-8-9.
Final Report of the Geological Survey of Nebraska, and portions of the adjacent Territories; by F. V. HAYDEN, with Map, 1871.
Preliminary Report of the United States Geological Survey of Wyoming, and portions of contiguous Territories; by F. V. HAYDEN, 1870.
Fifth Annual Report of the United States Geological Survey of Montana, and portions of the adjacent Territories; by F. V. HAYDEN, 1871.
Sixth Annual Report of the United States Geological Survey of Territories, embracing Montana, Wyoming, &c., for the year 1872.
Map of the Source of Snake River.
Map of Montana and Wyoming Territories.
Map of parts of Idaho, Montana and Wyoming.
Map of the Upper Basin, Fire-Hole River.

United States Geological Survey of the Territories—continued:—

Annual Report of the United States Geological and Geographical Survey of the Territories, embracing Colorado; by F. V. Hayden, 1873.

Geological Report of the Exploration of the Yellow-Stone and Missouri Rivers, with Map, 1859-60.

Synopsis of the Flora of Colorado; by Porter & Coulter.

Geological and Geographical Survey of the Territories, 1874

Descriptive Catalogue of the Photographs of the United States Geological Survey of the Territories, 1869-73; by W. H. Jackson

Meteorological Observations during 1872, in Utah, Idaho and Montana; by Henry Gannett.

Lists of Elevations in that portion of the United States west of the Mississippi River; by Henry Gannett.

Catalogue of Publications, United States Geological Survey of the Territories; by F. V. Hayden, 1874.

United States Geological Survey of the State of Iowa.–C. A White, M.D., State Geologist:—

Report of the Geological Survey of Iowa; 2 volumes, I-II.

United States Geological Survey of Illinois —A. H. Worthen, Director:—

Geological Survey of Illinois, Geology and Palæontology, Volume V.

United States Geological Survey of Ohio.—Prof. J. S. Newberry, Chief Geologist:—

Report of the Geological Survey of Ohio, and Atlas, Volume I, Part I.

Report of the Geological Survey of Ohio—Geology, Palæontology, Volume I, Part II.

United States Geological Survey of Missouri.—G. C. Broadhead, State Geologist:—

Report on the Geological Survey of the State of Missouri, 1855-71.

Preliminary Report of the Iron Ore and Coal Fields, from the field-work of 1872, with Atlas of 14 Maps and Sections.

Report by the Curators to the Governor, 1873.

Report of the Geological Survey of the State of Missouri, and Atlas; including field-work of 1873-74.

United States Geological Survey of California,—J. D. Whitney, State Geologist:—

Contributions to Barometric Hypsometry, with Tables for use in California.

New York State Museum of Natural History.—James Hall, LL.D., Director:—

Twenty-first	Annual Report	of the Regents	of the University,	1868.
Twenty-second	"	"	"	1869.
Twenty-third	"	"	"	1869.
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Twenty-fifth	"	"	"	1871.
Twenty-sixth	"	"	"	1872.

Fifty-sixth Annual Report of the Trustees of the New York State Library, 1873.

Board of Agriculture, State of Maine, U S.—S. L. Boardman, Secretary:—

Sixth and Seventh Annual Report of Agriculture and Geology; Second Series, 2 Volumes, 1861-2.

Board of Agriculture, State of Maine, U.S.—continued:

Report of the Agriculture of Maine; Second Series, 8 Volumes.

Provisional Report upon the Water-Power of Maine; by Walter Wells.

The Water-Power of Maine; by Walter Wells.

Report of the Commissioners of the Hydrographic Survey of the State of Maine, 1867.

Third, Eleventh and Nineteenth Annual Reports of the Secretary of the Maine Board of Agriculture, 1866, 1874.

A Survey of Waldo, County Maine; by J. W. Lang. 1873.

First Annual Report of the Secretary of the Maine State Pomological Society for the year 1873.

The Ornamental and Useful Plants of Maine; by F. L. Scribner.

Some Materials towards a History of the Cattle of Maine; by S. L. Boardman.

Harvard College, Cambridge, Mass., U.S:—

Catalogue of Terrestrial Air-Breathing Mollusks of North America; by W. G. Binney; Volume III, No. IX.

Ophiuridae and Astrophytidae, new and old; by Theo. Lyman.

Annual Report of the Trustees of Harvard College, 1872-3.

Boston Society of Natural History:—

Proceedings............... Volume XV, Part II-III-IV.
" .... " XVI, " I-II-III-IV.
" .... " XVII, " I-II.
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" .... Volume II, Part III, No. I-II-III-IV-V.

Academy of Natural Science of Philadelphia:—

Proceedings....... Part II and III, 1873. Part I-II, 1874.

Essex Institute, Salem:—

Proceedings.................. Volume IV and V 1872 3.

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Transactions......................... Volume III, No. I.

Peabody Academy of Science, Salem:—

Annual Report of the Trustees for the year 1873.

L'Académie Imperiale des Sciences de St. Petersburg:—

Memoirs VII................. Série Tome XI, No. 4.
" .... " " XVI, " 12.

James D. Dana, New Haven, Conn.:—

On the Quartzite Limestone and associated Rocks of the vicinity of Great Barrington, Berkshire Co., Mass.

C. H. Hitchcock and J. H. Huntington, Hanover, N.H.:—

Geology of the North-West Part of Maine.

United States Geological Survey of New Jersey.—Geo. H. Cooke, State Geologist:—

Annual Report of the State Geologist of New Jersey, for the years 1870, 1871, 1872 and 1873.

Geological Map of Northern New Jersey, 1874.

Atlas of Maps of the State of New Jersey.

Crown Lands Department, Province of New Brunswick :—
Thirteenth Annual Report, for the year ending October, 1873.
Map showing the Timber Lands of New Brunswick.

Industrial and Technological Museum, Melbourne :—
Lectures during the Autumn Session, 1874.

Geological Survey of the United Kingdom, London :—
Catalogue of the Published Maps, Sections, Memoirs, and other Publications, up to January 1, 1874.

PROFESSOR N. H. WINCHELL, M.A., State Geologist of Minnesota :—
First Annual Report of the Geological and Natural History Survey of Minnesota, for the year 1872. Extracted from the Regents' Report for 1872.
Annual Report of the Board of Regents of the University of Minnesota, for the year 1873.
The Drift Deposits of the North-West; by N. H. WINCHELL.

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Proceedings, 1869; Volume First.

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J. W. DAWSON, LL.D., F.R.S., F.G.S.
Report on the Geological Structure and Mineral Resources of Prince Edward Island, 1871.

SANDFORD FLEMING, C.E., Engineer in Chief, C. P. Railway :—
Report of Progress on the Explorations and Surveys, up to January, 1874.
Maps and Charts to accompany Report on the Explorations and Surveys, up to January, 1874.

Geological Survey of Scotland :—
Descriptive Catalogue of the Maps, Sections and Memoirs (published and in preparation), 1873.

JOHN B. PERRY, Cambridge, Mass. :—
A Review of Sir Charles Lyell's Students' Elements of Geology.

ALFRED R. C. SELWYN :—
New Zealand Exhibition, 1865. Reports and Awards of the Jurors, and Appendix.
Essays and Statistics on the Social and Economic Resources of the Colony of Victoria, 1873.

Geological Survey of Victoria :
Report of Progress, 1873.
Palæontology of Victoria, Decade 1; FREDERICK McCOY.

Massachusetts Institute of Technology :—
President's Report for the year, 1874.

THOMAS DEVINE, F.R.G.S. :—
Government Map of Part of the Dominion of Canada.

General Land Office, Washington :—
Map of the United States and Territories, 1874.

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Coal at Home and Abroad; J. R. Leifchild.
Coal-Regions of America; James Macfarlane.
Jahresbericht; Alex. Naumann
The Coal-Fields of Great Britain, 3rd Edition; Edward Hull.
The Journal of the Iron and Steel Institute, 1873.
Geological Map of the United States.
A Handy Book of Rock Names; G. H. Kinahan.
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Manual of Practical Assaying; John Mitchell.
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Flora Fossile Arctica, 2 Volumes; Dr. Oswald Herr.
Die Fossile Flora von Sotzka; Franz Unger.
Flora Tertiaria Helvetiæ, 3 Volumes; Dr. Oswald Herr.
The World before the Deluge; Louis Figuier.
Traite de Palæontologie Vegetale, with Atlas; W. P. H. Schimper.
Quantitative Chemical Analyses; Dr. C. R. Fresenius
Elements of Metallurgy; J. A. Phillips.
The Journal of Iron and Steel Institute, 1874.
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Cave Hunting; W. B Dawkins,
Determinative Mineralogy and Blow-Pipe; G. J. Brush.
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Mittheilungen; Dr. L. Elsner
Hughes' Photography.
Map of Canada; Jno. Johnston.
Etudes Critiques Sur Les Mollusques Fossiles, 4 Volumes; L. Agassiz.
Air as Fuel; Owen C. D. Ross, C.E.
Gazetteer of British North America; Lovell & Crosby.
The Year Book and Almanac of Canada, 1875.
Report on the Assineboine and Saskatchewan Exploring Expedition; H. Y. Hind.
Indexes and Maps to accompany Reports on Explorations in North America; Capt. Palliser.
Archiv fur Naturkunde; Volumes IV to VII.
Denkschriften der K. A. des Wissenchaften; Volumes XXVII-XXVIII.
Entwickelungsgeschichte des Amphioxus; Dr. A. Kowalevsky.
Embryologische Studien an Wurmern; Dr. A. Kowalevsky.
Geognostich Palæontologische Beitrage, I. 1-3 II., 1-2; Dr. E. W. Benecke.
Uber Ammoniten, 2 Volumes; Suess.
Palæontologische Mittheilungen; Drs. Oppel and Zittel.

A Discussion of the Law of Priority, &c.; W. A. LEWIS.
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Description Geologique et Paleontologique des Etages Jurassiques Superieures de la haute Marne; DELORIOL, ROYER et TOMBECK.
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Canada on the Pacific; CHARLES HORETZKY.
Peace River; MALCOLM MCLEOD.
Victoria and British Columbia; MACFIE.
Queen Charlotte Islands; POOLE.
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Paleontologie ou Description des Animaux Fossiles de la Province D'Oran; A. POMEL.

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Annales de Chimie et de Physique, Paris.
Annales des Mines ou Recueil des Memoires sur L'Exploitation des Mines, Paris.
American Journal of Science and Arts, New Haven, Conn.
American Chemist, New York.
Chemical News, London.
Comptes Rendus, Paris.
Canadian Naturalist, Montreal.
Canadian Patent Office Magazine, Montreal.
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Journal of Chemical Society, London.
Journal of Science, Metals and Manufactures, London.
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Mining Journal, London.
Nature, London.
Popular Science Review, London.
Philosophical Magazine, London.
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Quarterly Journal of the Geological Society, London.
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The Iron Age, New York.
The Geologist, London.
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REPORT

ON THE

COUNTRY WEST OF LAKES MANITOBA & WINNIPEGOSIS,

WITH NOTES ON THE

GEOLOGY OF LAKE WINNIPEG,

BY

ROBERT BELL, C.E., F.G.S.,

ADDRESSED TO

ALFRED R. C. SELWYN, F. R. S., F. G. S.,
Director of the Geological Survey of Canada.

——:o:——

MONTREAL, 18th February, 1875.

Sir,—I beg leave to report the results of my geological exploration in the North-West Territory during the past season, which was, to some extent, a continuation of that of the previous year.

The following instructions, which I had the honour of receiving from you before starting, will best explain what was intended to be done during the season:—

" MONTREAL, 6th June, 1874.

Instructions.

" My dear Sir,—With a view of prosecuting the geological exploration of the Province of Manitoba and the North-West Territories during the present summer, I have to request that you will, as soon as possible, proceed to Fort Garry, either *via* Duluth or the Dawson Route, and there organize a party for the purpose of making as thorough an examination and survey as possible, of as much of the country as the time and means at your disposal will permit, lying to the west of Lakes Manitoba and Winnipegosis and east of the valley of the Assineboine River, including the Riding, Duck and Porcupine Mountains, and the Pasquia Hills. You will, of course, pay particular attention to investigating the truth of the

Region to be explored.

reported occurrence of lignite or coal in this region; and also, if possible, endeavour to establish and define the eastern limits of the Cretaceous rocks and their relation to the Devonian, Silurian or other older rocks which succeed them in that direction.

"You will probably find Fort Pelly the most convenient head-quarters from which to draw supplies and send and receive communications.

"It has been decided to make a bore in that vicinity, and I have arranged for a party to be sent there for that purpose from Petrolea, under Mr. Joseph Ward. As you will arrive there in advance of the boring party, it would be desirable that you should make an inspection of the ground, and select a sight for the bore-hole in such a position as to avoid, if possible, the having to penetrate a great thickness of drift before reaching the rock; also as conveniently situated as practicable as regards timber suitable for derrick, walking-beam and other purposes, as well as obtaining the requisite supply of water and fuel for the engine.

"It would likewise be desirable that the site of the bore should be located on government land and outside the limit of any reserve or preemption of the Hudson's Bay Company.

"From the enclosed copy of a letter, kindly sent me by Colonel Dennis, you will see that he has instructed Mr. Hart, the Inspector of Dominion Land Surveys at Winnipeg, to facilitate your obtaining supplies from any of their depôts which may be located near the country in which your work lies.

"In organizing and equipping your party, you will use the utmost economy which may be consistent with the efficient performance of the work, and the total expenditure for the season's exploration must not exceed ($2,000) two thousand dollars.

"Yours very truly,
"(Signed,) ALFRED R. C. SELWYN.

"PROF. R. BELL, C.E.,
"*Geological Survey of Canada.*"

Montreal to Fort Pelly.

In pursuance of these instructions, I left Montreal on the 12th of June, for Manitoba, via Duluth, and reached Fort Garry on the 30th. Here I met Mr. J. W. Spencer, whom you had recommended as my assistant, and who had preceeded me so far. Fort Garry being our starting point, a few days were consumed here in organizing a party, securing supplies and making the necessary preparations and arrangements for the season's operations.

After carefully considering the cost of the various means of reaching Fort Pelly, which you had indicated as our most convenient head-quarters, and also of transporting our provisions and camp equipage in the course of our explorations after getting there, I decided in the first place, to hire four carts and five horses to carry our outfit to Fort Pelly; the service to be paid for on the return of the "train" to Fort Garry. Working from Fort Pelly, as a centre, we found it necessary to employ a variety of means of transportation according to circumstances. In the course of our travels, we made use of horses and carts, or of pack-horses hired from the Hudson's Bay Company, a skiff which we had taken with us, a flat-bottomed boat, bark canoes, and sometimes we travelled on foot, carrying our packs.

Means of conveyance.

In the country which we explored, there is but little of direct geological interest in proportion to the area, and therefore, considerable time must necessarily be spent, and much ground gone over, in order to ascertain even a few facts. This arises from the great depth of the superficial deposits which almost everywhere cover up and conceal the fundamental rocks, together with the nearly horizontal attitude of the latter, and their poverty in fossils, on which we are obliged to depend for the determination of the horizon of such exposures as do occur.

Rocks concealed.

It will be seen by the following report, that we managed to examine all the ground covered by your instructions, with the exception of the most distant part—the Pasquia Hills—for the exploration of which it was found there was not time. In returning from Lake Manitoba, towards the close of the season, I came by way of Fairford, St. Martin's Lake, the Little Saskatchewan River and Lake Winnipeg. This gave me an opportunity of examining the rocks along the eastern shore of the latter lake, from the narrows at the Dog's Head to the mouth of Red River.

Party.

My party for the season, consisted of Messrs. J. W. Spencer, B.A.Sc., William Hagar, James Sheriff, Edward Stanley and Samuel Bruce. In addition to these, Half-breeds and Indians were employed for shorter periods, as circumstances required. My total expenditures, including the salary of my assistant, after deducting the value of supplies left over, fell considerably within the limit ($2,000) which you had fixed.

Cost of exploration.

Arrangement of Report.

In this report, I propose to give an account of our proceedings, *seriatim*, noting anything that may be of value in the way of information, concerning the regions explored, and describing our geological observations in the course of the narrative. I also propose to add some notes on the natural history of the region, believing that e very such contribution to science will some day prove of more or less value. Although my party was small, I managed to get along after dividing it, so as to allow Messrs. Spencer

Hagar and Bruce to work on separate ground during most of the season, and thus we were able to accomplish more than would have been possible in the same time, had we all kept together. The result of the labours of this section of my party, are given in the accompanying report by Mr. Spencer.

Division of party.

We left our camp near Fort Garry on the afternoon of the 8th of July, and reached Fort Pelly on the 25th of the same month. At Prairie Portage, I obtained from Mr. Alexander McDonald (in charge of the boring party at Rat Creek) two horses, two carts, and one man to assist in taking up our freight, on condition that they would be returned in twenty days. They accompanied us to the junction of the Shell River with the Assineboine, from which I sent them back, and they reached Rat Creek again on the twentieth day.

Fort Garry to Fort Pelly.

From Prairie Portage we followed the northern trail, which crosses the White Mud River, first at Westbourne, then at Woodside, and finally at Palestine, or the "Third Crossing," and passes over the southern prolongation of the Riding Mountain. While our carts were going directly to Westbourne, I rode from Prairie Portage to Green's Farm on Portage Creek, near Lake Manitoba, and thence in as straight a course as possible to Westbourne. In going northward from the village of Prairie Portage, there is a gentle rise in the surface for about four miles, after which it begins to fall very gradually towards Lake Manitoba. The ground in the above distance, in many places, is thrown into a series of ridges and hollows, the former varying from two to six chains apart, and from three to eight feet in height. The subsoil, as seen wherever wells have been dug, consists of greyish sand, without observed boulders, holding fresh water shells; among which are species of *Cyclas*, *Limnæa* and *Physa*. Good water has been found in all the numerous wells which have been dug in the tract between the Assineboine River and Lake Manitoba, at depths varying from four to fifteen feet. In attempting to follow a straight course from Green's Farm, which is in Section 17 of Township 13, Range VI, west, I came upon both Cram Creek and Oak Creek, two long marshy canals, extending from the lagoons of Lake Manitoba, and was obliged to diverge some distance to the southward, in order to get round their southern extremities.

Route.

Sand containing fresh-water shells.

Creeks.

From Totogon to a point some distance above Westbourne, the course of the White Mud River is marked by groves of trees, consisting principally of elm and oak. The ground close to each side of the river is somewhat higher than that of the prairie a short distance off, and many pebbles and boulders are scattered upon the surface of this raised strip of land, while further away but few are to be seen. From Westbourne to within

White Mud River.

Soil.

about eighteen miles of the Rapid (or "Little Saskatchewan") River, the soil, judging from what may be seen along the trail, is of a light sandy nature; but in the above eighteen miles there is a great improvement. The level sandy land is replaced by a hilly region, in which there is a beautiful mixture of openings, covered with bright green grass and wood, interspersed with numerous ponds and small lakes. The soil is almost free from boulders, which, however, are found plentifully on the slopes of the Rapid River. Beautiful Plain, on which the Government provision depôt is situated, in Township 15, range XIV., W., consists of a low wide straight ridge, about twenty-four miles in length, running in a north-north-westerly direction. It is composed of sand and gravel, with a smooth surface supporting a scanty growth of wiry grass, and is bordered with trees on either side. It rises gradually from the east side, but falls off abruptly on the west, along which the Little Saskatchewan or Rapid River flows southward. We observed a similar ridge lying parallel to Beautiful Plain, and within a distance of about three miles to the eastward of it. Other similar ridges occur to the east of these, further north. They all resemble great artificial avenues cleared in the woods. The trail crosses Stoney Creek about eighteen miles west of Beautiful Plain. In the central part of this interval, which would be in Township 15, Range XV., W., we passed over a number of long low parallel ridges of washed gravel, running with great regularity in a northerly and southerly direction, and having good land between them.

Beautiful Plain.

Ridges of sand and gravel.

Shale.

Shale having been reported as occurring in the beds of brooks in the Riding Mountain region, I searched for it in several of them between Beautiful Plain and the Rapid River, but did not succeed in finding it in place, although small fragments were abundant. From the Rapid River to Fort Ellice the soil is generally good, the prevailing character being a sandy and gravelly loam, with a fair coating of black mould over the surface. Boulders are not often so abundant as that they would interfere seriously with agricultural operations, except for a distance of five or six miles between Snake Creek and Fort Ellice, and even here they appear to be confined to a limited area, as they are not common on the trail to the "Freemen's Crossing" of the Assineboine, a few miles to the northward of that leading directly to Fort Ellice.

Boulders.

Gravelly and sandy tract.

On the west side of the Assineboine River, a barren tract extends for some distance around Fort Ellice. A coarse sand, with gravel, prevails on either side of the Calling River Valley, for twenty miles westward from its junction with the Assineboine. A few miles south of the Calling River, this sand is replaced by a surface thickly strewn with Laurentian boulders, mostly of small size, and this bouldery character prevails for some miles both east and west of the twenty miles just indicated. Northward from Fort Ellice, the trail to Fort Pelly on the west side of the Assineboine River, passes over the sandy tract for about fifty miles, beyond which the soil improves, and trees and bushes gradually replace the nearly open prairie. The dwarf or creeping variety of the red cedar, *Juniperus Virginiana,* (Linn.) var. *humilis,* spreads itself almost everywhere over the sand.

Shell River exploration.

When abreast of the mouth of Shell River, which enters the Assineboine from the east, about fifty-five miles from Fort Ellice, and sixty-five from Fort Pelly, I left Messrs. Spencer, Hagar and Bruce to explore the Shell River and other branches of the Assineboine, after which they were to rejoin me at Fort Pelly. The result of these explorations are given in Mr. Spencer's report which accompanies this. From this point to Fort Pelly, the soil is generally of a fair quality, and is usually overgrown with willow shrub and other bushes; or, groves of aspen trees. Several small tributaries of the Assineboine River from the west, cross the trail in this distance. The largest of them are Stoney, Steep and White Mud Creeks. For about twenty miles before coming to Steep Creek, we passed numerous groups of large gneiss boulders, most of them sunk nearly to their tops in the ground. At the crossing of White Mud Creek, a peculiar soft, muddy marl, and an abundance of clay-ironstones appeared to indicate the proximity of certain beds of the Cretaceous system *in situ,* as similar marl and ironstones belonging to this divison were afterwards found, in place, in the beds of the Assineboine and Swan Rivers. The point at which the trail crosses the White Mud Creek, is about eighteen miles south of Fort Pelly.

Trail to Fort Pelly.

Cretaceous marl.

Courtesy of H. B. Co.

After storing our provisions, &c., at Fort Pelly, I immediately sent back the horses and carts, and the two half-breed drivers we had brought from Fort Garry. For the safe storage of our supplies and the accommodation of horses, &c., which we subsequently required, we were indebted to the officers of the Hudson's Bay Company; and I would here beg to acknowledge the kind assistance which we received at Fort Pelly and ten other posts of the Company, at which different members of our party had occasion to call during the season.

Assineboine Valley.

For twenty-five miles below Fort Pelly and an unknown distance above it, the valley of the Assineboine is ill defined, and the river itself winds about in an extremely tortuous course, but at about the above distance, in a straight line below Fort Pelly, it enters a very regular ravine, averaging from half a mile to a mile in width between the brinks of the banks, which vary from about 100 to a little over 200 feet in height.

In the valley of the Assineboine River at Fort Pelly, the soil is good, and here the Hudson's Bay Company have frequently tried to cultivate wheat, but it always fails to ripen, owing apparently to the chilling influence of the fogs which usually lie in the valley in the cold mornings of the latter part of the summer. On the higher ground the soil is of a poor sandy character for five or six miles to the north, and also for some distance to the south of the valley.

Branches of Assineboine.

Between Fort Pelly and the Shell River, which, as already mentioned, is about sixty-five miles down, the principal tributaries of the Assineboine from the east, are Little Boggy Creek, at about twenty-five miles, and Big Boggy Creek at about forty-seven miles from Fort Pelly. These two streams are rapid brooks, the term "creek" being used in this region as elsewhere in America, instead of brook. Having made the necessary preparations for an exploration of the Duck Mountain region, I left Fort Pelly on the afternoon of the 28th July, and the same evening camped at a place known as the Crow-stand, on Little Boggy Creek, about five miles from its junction with the Assineboine River, and nineteen miles in a south-south-easterly course from Fort Pelly. Between Fort Pelly and the Crow-stand, the soil is of a sandy character, but generally of a fair quality and nearly free from boulders. In approaching the Crow-stand, several hills, which however shew no signs of solid rocks, rise to heights of upwards of one hundred feet, a short distance to the east of the course we followed.

The Crow-stand.

Lignite.

As there were rumours of coal or lignite having been found in the Little Boggy Creek, I left two of my party camped at the Crow-stand to search for it, till I should return to them. They found no trace of it after having hunted both in the creek and in the Assineboine River, above the junction of the two streams.

Exploration of Duck Mountain region.

Following a south-east course from the Crow-stand, I first passed along the south-western base of a bouldery ridge, about a mile in length, having the same direction, and at the end of eleven miles, came upon Big Boggy Creek, flowing east-north-east. This I descended for about eight miles without finding any solid rock, and then struck north-north-eastward through a level country with a good clayey and gravelly loam soil. It is covered with brush, broken by ponds and prairie openings. We also passed through a strip of large timber, a mile and a-half in width. The trees consisted of aspen and balsam-poplar, spruce and tamarac. With the exception of a few trees on the south side of the Assineboine, near Fort Pelly, spruce and tamarac were first observed on coming to the Big Boggy Creek. Some of the tamaracs were upwards of a foot in diameter.

Timber.

Upper Shell River.

Following the above north-north-eastward course from the Big Boggy Creek, at about ten miles, I came upon a westward bend of Shell River, at a point where it is joined by a brook from the west. I then traced this river upwards for about twenty-one miles, the general bearing being about north. In this part of its course it flows in a well-marked valley, about half a mile in width between the brinks of the banks, and a quarter of a mile in the bottom. The banks are composed of drift material, and average 100 feet in height, although in one place the barometer indicated a height of 180 feet. The bottom of the valley and the slopes of the banks facing southward and eastward, are usually destitute of trees, but otherwise this region is well wooded. The timber consists of spruce, in groves on the banks, and sometimes in the bottom of the valley, with aspen and balsam-poplar on the table-lands on either side. The river itself is a small stream which winds its way smoothly and quietly from side to side of the valley, interrupted only by an occasional beaver dam, or a slight rapid, over a bar of boulders or gravel. I could discover no rocks *in situ*, either in the bed of the river or in its banks, although they were carefully looked for in both. In one place near the termination of our exploration of the valley, the east bank was covered with travertine or consolidated calcareous tufa, portions of which have slid, in mass, on the clayey base on which it all rests, and become broken into angular blocks. The soil in parts of the bottom of the valley, and almost everywhere on the plateaux on either side, appeared to be of excellent quality, consisting in some places of clayey, and in others of sandy loam.

Big Boggy Creek.

Returning to the point at which we had crossed Big Boggy Creek, eight miles below where we had first struck it, we traced it to its junction with the Assineboine River, a distance of about twenty-four miles, following its general course, making in all about thirty-two miles explored along this stream. The valley of Big Boggy Creek is of the same character as that of Shell River, but on a somewhat smaller scale. The table-land east of the upper part of the river, into which we made an excursion of some miles, was found to be of an open marshy character, with numerous shallow muddy ponds, surrounded with reeds and tall grass; among which, large numbers of wild ducks find their breeding places.

We had been informed by some Indians that we would see fixed rocks of various colors at one place in this valley, but although we found the exact spot which they had indicated, the rocks turned out to be small rounded boulders, in a high bare bank of earth. The only rock *in situ*, which I could discover on this creek, occurred about two miles from its junction with the Assineboine River, which, as already mentioned, is about forty-seven miles below Fort Pelly. It consists of a section in the bank of the brook of about fifteen feet of clayey shale, of a greyish indigo or leaden color, when moist, holding large flattened circular nodules of clay-ironstone. Many of these nodules which have been washed from the bank, lie in the bed of the stream. Some of them shew transverse cylindrical portions of a darker color than the msss, and also transverse cracks filled with yellow calcspar. The apparent dip is westward, at an angle of about 7°, but this may not be the true dip, as the whole mass may have been affected by an ancient land slide.

Shale.

From the above point on Big Boggy Creek, I followed a straight north-north-westerly course back to the Crow-stand, the distance being about twenty-six miles. Most of our course lay several miles to the east of the Assineboine River. In the above interval the soil is sandy; in some places light and poor, but generally mixed with loam and of a fertile character. Boulders were scarce, except near the Crow-stand. The surface of the country is slightly undulating. Rather more than half the area consists of prairie openings, the remainder being covered with poplars and willows. In the prairie portions, the moles have thrown up almost every foot of the soil into little hummocks, often for miles at a time. Surface water was scarce when we passed over the ground in the beginning of August.

Soil.

On the 5th of August, I sent a man with a horse and cart from Fort Pelly to Shell River, to bring back the party which had been left behind (when on our way up) to explore in that neighbourhood; and, the same afternoon, started to make a preliminary reconnaisance of the Swan River valley. I might here mention that the results of Mr. Spencer's exploration of the lower part of the Shell River, and my own of a section of the same stream higher up, and also of the Big and Little Boggy Creeks, show that all these streams flow much more nearly parallel to the Assineboine River than represented on the published sketch-maps of the region.

Parallelism of streams.

The trail from Fort Pelly to Swan Lake crosses the Swan River about twelve miles north-east of the Fort, and continues thence on the north-west side of the river to a point which is counted as seventy miles from Fort Pelly and fourteen above Swan Lake, where it recrosses to the south-east side of the river. Some years ago, this trail was measured, and stakes were planted at every mile, and although these have now disappeared, my intelligent half-breed guide, Peter Brass, remembered where the more important ones had stood, and I found the distance thus given to agree very well with my own reckoning. On the east bank of the valley of Snake Creek, which the trail touches a few miles north of Fort Pelly, numerous blocks of yellowish-grey limestone are mixed with the pre-

Fort Pelly to Swan Lake.

vailing gneiss boulders. These were being collected, and burnt in a kiln to an excellent white lime for the supply of Fort Pelly. At the Swan River Crossing (twelve miles from Fort Pelly), a soft bluish-grey shale occurs in the south bank of the river. It lies about horizontally, and shows numbers of clay-ironstone nodules, many of which also lie loose at the bottom of the bank and in the bed of the river. Immediately after crossing Swan River, we entered the Five-mile Woods. The trees are mostly aspen and balsam-poplar, with some spruce and white birch. In the woods, the soil is an excellent clayey loam, overlaid with black mould. Emerging from the Five-mile Woods, we entered upon the Square Plain, which has a length, on the trail, of about sixteen miles. In the first or southern six miles of this distance, prairie openings alternate with groves of aspens, and the soil is of a coarse sandy character, with some gneiss boulders. The remaining ten miles consist of prairie, with bushes in some places; and the trail passes over a fine loamy soil—the best we had seen since leaving the fertile prairie land of the lower Assineboine valley. The sandy soil in the southern part of the Square Plain is furrowed by old buffalo tracks running in the same direction as the trail. Thunder Hill lies on the western side of the Square Plain, and the brook named after the hill joins the Swan River near its eastern corner. Leaving the Square Plain, we passed through The Poplars, which have a length of about five miles on the trail; and after crossing a short interval of dry sandy land, entered upon the Great Meadows, which are said to extend all the way to "the Store," at the second crossing of the Swan River. In going through The Poplars, the trail in the second or eastern half of the distance runs along the top of a ridge of shingle, varying in height from four to twelve feet, but averaging from five to eight, and having a width of from one to three chains. It is composed mostly of pebbles of gneiss and grey limestone, and is flanked by a swamp on each side. The Great Meadows have a level dreary appearance, and are overgrown with rank sedges, grasses and vetches, interspersed with clumps of willow bushes. They would yield an almost inexhaustible supply of excellent fodder for cattle and horses. The soil is a rich black loam, but apparently too wet for cultivation without drainage; which, however, could be easily effected, as the surface is thirty or forty feet above the level of Swan River. The remains of ancient beaver-dams are a noticeable feature in this area. Owing to the level nature of the ground, they have necessarily been built of a great length. They are now all dry, with the exception of a little water at the gap, which is opened through the lowest point in each of them. These old beaver-dams may be taken as one of

Shale *in situ*.

Five-mile Woods

Square Plain.

Thunder Hill.

The Poplars.

Shingle ridge.

Great Meadows.

Dry beaver dams.

the evidences of the greater abundance of water in this region in former times.

When at a point on the trail, upwards of fifty miles from Fort Pelly, we turned off to the east, and after going three miles through willow brush, with small prairie openings, in which the grass and vetches were as high as our horses' backs, we came upon the north-west bank of Swan River, about four miles above the junction of Sander's River, which enters from the opposite side. Here I found, at the bottom of the bank, a cliff ten feet high, extending for several chains, and consisting of bluish drab or greyish marl, interstratified with a few thin interrupted beds of ferruginous sandstone, and holding reniform nodules of iron pyrites. A very dark blue, or almost black stiff clayey marl was seen higher up in the bank, and again on the edge of the river at the upper end of the cliff. At one place in the face of the cliff, and near the top, there is a layer of broken lignite a few inches thick, lying horizontally, like the marl in which it occurs, and apparently in place, its fragmentary condition being evidently due to the force of the ice and drift timber at high water. In following the bed of the river for about two miles upward from this spot, I picked up numerous fragments of similar lignite in the shingle. It closely resembles the lignite collected last season from the Tertiary strata south of the Calling River, but the rocks of the Swan River valley are probably all of Cretaceous age. At the end of the above two miles, the north-west bank of the river is about thirty-five feet high, and consists of solid rocks, with the exception of ten feet of drift at the top. The cliff presents a broken or "ruinous" condition, owing to frequent small land-slides, which prevent a continuous section of the whole of the beds from being seen. The lower fifteen or twenty feet consist of greyish sandstone; most beds of which are soft and charged with iron pyrites, which in some of the layers, constitutes fully half the weight of the rock. On exposure to the weather, the pyrites decomposes rapidly, causing the rock to crumble, and in dry places, depositing much dirty green sulphate of iron upon the surface. Opposite to the cliff the river-bed is encumbered with blocks of fine-grained grey sandstone; some of them two and a half feet thick, which appear to have been derived from the harder portions of the lower beds of the cliff, of which only an imperfect section is seen. Along with these sandstone blocks I noticed several nearly spherical concretions of the same material, the largest one measuring five or six feet in its greatest diameter. They were somewhat flattened vertically, and in one instance, three of them were observed to coalesce at their edges. Overlying the pyritiferous sandstone are ten feet or more of blackish-blue clayey marl, similar to that occurring in the

Rocks *in situ*.

Lignite.

Sandstone with iron pyrites.

Spheroidal concretions.

bank of the river two miles below. The upper beds of the sandstone hold fragments of lignite, and their surfaces are marked by a few rusty impressions of plant remains. One of these embedded fragments of lignite contains a piece of bright yellow resin.

Timber.

On the banks of Swan River in this neighborhood, I observed, in addition to the prevailing aspen and balsam-poplar, oak trees fifteen inches in diameter, and thirty feet high, elm, black ash, white birch and ash-leafed maple. Occasional small trees of all these species were also noticed as far up as Swan River Crossing, where spruce of fair size is likewise found.

Character of Swan River.

Swan River is a very rapid stream, the descent from The Crossing to Swan Lake amounting to about 500 feet, and its bed is so encumbered with boulders, as to render its navigation difficult at all times. The water is very low in August and September, and we were advised against attempting to descend it with any kind of craft; but as my journey on horse-back down the valley had convinced me that the only way to examine or even find all the rock exposures which might occur along the river, was to follow the stream itself; I decided to send Messrs. Spencer, Hagar and Bruce in a small flat-bottomed boat, which I obtained from the Hudson's Bay Company at Fort Pelly. I gave Mr. Spencer instructions also to examine Thunder Hill, Porcupine Mountain, and if time permitted, the Pasquia Hills, and then to proceed to Fort Garry by way of Lakes Winnipegosis and Manitoba, collecting as many fossils as possible, and making what geological observations he could on the journey. It had been my intention to explore Sander's River for lignite, which was reported to occur there, but finding on going near the place, that it could be best done by means of a boat, I included the examination of this stream in Mr. Spencer's instructions. His report on all these matters accompanies this.

Mr. Spencer's instructions.

Start to descend the Assineboine River.

The same day (August 17th) that Mr. Spencer left Fort Pelly, I also started from that place in a skiff with two men, to follow the Assineboine River and examine its bed and valley to Fort Ellice. Up to this date, I had found no locality nearer Fort Pelly than the Swan River Crossing, at which rock older than the drift came to the surface; but I expected to be able to do so in the bed of the Assineboine River, in which event I would have sent back a letter to Fort Pelly. I had so far heard nothing of the boring party—not even that they had left Petrolia. However, before quitting Fort Pelly, I left instructions with the gentleman in charge, that should they, by any chance, arrive before I had discovered a better site, or had an opportunity of communicating with them myself, he should send them on to the Swan River Crossing. Full particulars in reference to this matter are contained in the letter I had the honor of addressing to you on the subject, on the 30th December last.

haracter of the ssineboine iver.

The whole course of the river from Fort Pelly to Fort Ellice is extremely tortuous, especially towards the former, where the distance between two points is often two or three times as great by the river as in a straight line. Starting from one side of the valley, the river will frequently, after describing a loop a mile or so in length, return to within a few yards of the same spot. The distance by the river between the two forts, we estimated to be about 270 miles, and in a straight line about 130. The river itself has very much the same character the whole way. At low water, the laminated alluvial clay of the valley forms a cliff from ten to twenty feet high at the concave side of every bend, or alternately on the right and left, while on the opposite side there is a sloping bank of silt, covered with willows. These clay cliffs usually overhang at the top, owing to the tenacity imparted to the upper layers by the roots of plants, and they thus afford shelter for thousands of nests of the cliff swallow, *Hirundo fulva* (Vieill), which are all formed of a gourd shape, and generally with long-necked entrances pointing downward. The soil in the bottom of the valley, which averages about half a mile in width, is generally good, but there are many marshes and ponds above the immediate banks of the river. The bottom and banks of the valley are mostly open prairie, but numerous small ash-leafed maples grow among the willows along the river, and scattered trees and small groves of aspen, balsam-poplar, elm, black ash, white birch and oak occur in the valley.

›cks *in situ*.

The rocks exposed along the river are of one character throughout the whole of the above distance. In almost every case where the stream impinges against the bottom of either of the main banks of the valley, a bluish-drab or grey marl is exposed. It is usually of a soft or clayey nature, but occasionally assumes a distinctly shaley character. At each place it holds nodules of clay-ironstone, and, in some instances, arenaceous concretions. In one locality, nodules of gypsum, having a radiating crystalline structure, were washed from the bank. Upwards of thirty of these exposures were noted, but they do not require separate descriptions. At each exposure of marl in the bank, a little rapid, with boulders, occurs in the stream. The river was swift and shallow throughout when we descended it, and only wide enough to allow room for our oars; but the navigation is, of course, much easier at high water.

ight of banks.

The height of the banks of the valley averages about 175 feet, and appears to correspond nearly with the depth of the drift, so that the valley would seem to be excavated in the latter down to the level of the underlying rocks. The same conditions also appear to obtain in the other principal valleys in this region, as they all resemble each other in various respects.

Reduced size of tributaries before entering river.

In many cases, the tributaries of the river appear to loose themselves or become very much reduced in size on entering the flat ground at the bottom of the valley, so that they cannot be recognized at the margin of the main stream at low water. I observed the same phenomenon the previous year in reference to the tributaries of the Calling River.

Fort Ellice to Totogon.

From Fort Ellice we had our skiff transported on a cart to Prairie Portage, and thence to Totogon, on the White Mud River, close to its mouth, at the south-western extremity of Lake Manitoba. From this place we coasted along the west side of the lake, intending to go on to Lake Winnipegosis, and, after meeting with Mr. Spencer, to complete what work he might not have had time to accomplish. But, owing to delays from stormy weather, I found I would not be able to reach the northern part of the latter lake in time to be of any service before the close of the season, and I decided to return to Fort Garry by the route already mentioned, through St. Martin's Lake and Lake Winnipeg. I was the more induced to take this course from the fact, that hitherto we knew very little about either the character or the arrangement of the rocks of the eastern shore of Lake Winnipeg, and that more information would be very desirable, especially as some important discoveries of minerals were said to have been made on this shore during the summer.

Lake Manitoba to L. Winnipeg and Fort Garry.

West side Lake Manitoba.

The western shore of Lake Manitoba to within about twenty-five miles of Manitoba House, is bordered by extensive marshes and lagoons, separated from the lake by beaches and islands of sand and gravel. Towards Manitoba House there is much good land near the shore, and a short distance back from the lake there are extensive openings, covered with good grass, which are already used for pasturing large numbers of cattle.

Limestone.

On the west side of the Narrows, there is an exposure of compact brittle limestone of a reddish-drab colour, thickly marked by spots and small strings of a deeper colour. It is also studded with clear crystalline grains of calcspar, and appears to be a pure limestone. The beds are from three to ten inches in thickness; the whole section only amounts to a few feet. I could detect no fossils in these rocks; but, from their position, they are, no doubt, of Devonian age. The island at which Professor Hind obtained Devonian fossils is near by, and the strata lie almost horizontally, the dip being at a very low angle to the westward. On the east side of the lake, about twelve miles south of Fairford, some short cliffs of limestone rise to heights of from ten to twenty feet above

Cliffs at Steep Rock Point.

the water on Steep Rock Point. The limestone is in rather thin beds with rough surfaces, and besides being very brittle, is of a nodular or incoherent character, so that it is difficult to break out even a hand-specimen without flaws. It is made up of rounded compact portions, having a smooth fracture and reddish-drab colour, imbedded in a somewhat less compact and lighter coloured matrix. Both parts hold spots and strings of white crystalline calcspar, and the whole mass is apparently a pure limestone. The beds lie nearly horizontally. No fossils were found after a careful search for them.

Fairford.

From the outlet of Manitoba Lake, the Fairford River flows swiftly for about two miles, and then opens out into a small marshy lake, called from its form the Partridge Crop, and after a short contraction enters St. Martin's Lake. The mission of Fairford and the Hudson's Bay post of the same name, are situated on the south side of the river, just above where it enters Partridge Crop Lake. St. Martin's Lake, which has a total length of nearly forty miles, is surrounded by level ground and marshes, and has a dreary appearance. The water is shallow, and its surface broken by numerous low bouldery points, reefs and islets. The only rock in place known to occur on the lake, is the gneiss which was met with by Professor Hind on some small islands towards the north-eastern extremity. After I left the lake, one of my Indians informed me that there was a low cliff of limestone in the woods about two miles west of the most northerly bay, out of which the Little Saskatchewan River flows. This river is a large stream, two or three hundred feet broad, with a good depth of water, except in the rapids, which occur here and there all along its course. They are all short, however, except the last one, which has a length of four miles, and terminates about a mile from the mouth of the river. Notwithstanding this rapid, which offers the most serious obstruction to the navigation of the river, it may be found possible to take small powerful steamers of shallow draft, from Lake Winnipeg to Lake Manitoba. At the head of the four mile rapid, there is a small exposure of thinly bedded, flat-lying limestone on the south side of the river, and at the foot of the rapid, limestone interstratified with shale, is seen on both sides of the river. It is of yellowish and greenish grey colors, and has a magnesian character. The dip is south-westward at an angle of about 5°. I noticed a large obscure *Orthoceras* in one of the beds, and collected a tolerably well-preserved *Pleurotomaria* and a *Rhynconella*, resembling the Hudson River form of *R. increbescens* (Hall.)

St. Martin's Lake.

Little Saskatchewan River.

Magnesian limestones.

Fossils.

The Little Saskatchewan River falls into a large bay on the west side of Lake Winnipeg, about midway between its northern and southern extremities. Between the bay and the narrows at the Dog's Head (where the lake is only about a mile and a half wide), dolomites are exposed in low cliffs on most of the head-lands. They have a nearly horizontal attitude, and are generally thinly bedded, of light greyish and drab colors, and hold but few fossils. At Stoney Point the rock is a beautiful soft fine grained, cream-colored dolomite, resembling the Guelph stone, but it is usually thinly bedded, and holds rounded, chalky-white nodules, which, however, are not calcareous.

Light-colored dolomites.

None of the published sketch-maps of Lake Winnipeg represent the shores or islands at all correctly; in fact, it would be impossible with any of them to recognize, even approximately, one's position in travelling through the lake. The country on both sides of Lake Winnipeg has a generally level aspect, and is apparently everywhere well wooded. Following the east shore from the Dog's Head southward, the rocks, which are almost continuously exposed, consist for the first thirty miles of Laurentian gneiss, generally massive and of the ordinary greyish and reddish varieties. The run of the stratification is pretty uniform, and averages from 50° to 60° south of east by the compass, and thus strikes inland at a small angle to the general course of the shore. At the above distance from the Dog's Head, or when within about sixty miles of Fort Alexander, a somewhat coarse-grained, greenish-grey, silvery, mica schist makes its appearance, with the same run as the gneiss. This and finer grained varieties of greenish mica schist, all of which may be considered Huronian, hold the shore for upwards of forty miles, or to within about fifteen miles of Fort Alexander, where gneiss again appears. Owing to a fever from which I was suffering, I was unable to make as thorough an examination of this coast as would have been desirable, but there appeared to be really very little of interest in the part which came under my observation, beyond the fact that the course of the stratification is almost at right angles to the general strike of both the Laurentian and Huronian rocks in the great region already explored to the north and north-west of Lake Superior, and also of the existence of the Huronian belt above referred to. The reported discovery of copper was based on the finding of specks of the yellow sulphide in white quartz strings, in some loose pieces of grey quartzite. No actual discovery of gold or silver appears to have yet been made. The discovery of coal on the east side of the lake was of course, extremely unlikely from all that had hitherto been known about the geology of that region, and what had been mistaken for anthracite, proved to be a black shining hornblende rock. I was informed that specimens of black shale brought to Fort Garry by Indians who pretended

No good maps of L. Winnipeg.

Rocks of the east shore of L. Winnipeg.

Reported discoveries of minerals.

to have found them on the east side of Lake Winnipeg, had also given rise to rumours of a coal discovery, but it turned out that even these specimens had come from elsewhere. I may mention that I have seen specimens of excellent red hematite in the hands of a gentleman, who said that he had collected them himself, at a locality somewhere between Berren's River and the Dog's Head. Mr. McArthur, who owns the saw mill at Fort Alexander, gave me a specimen of iron pyrites, which he informed me came from an island near Berren's River. Mr. Hoffmann of the Geological Survey, has made a careful analysis of this mineral, and found it to contain 0.207 per cent. of cobalt and nickel; mainly the former.

Return home. I arrived at Lower Fort Garry on the 14th of October, and four days later Mr. Spencer's party reached Winnipeg. I immediately paid off all the men, but was myself obliged to remain two weeks at the Lower Fort until I had sufficiently recovered from the fever to be able to travel; and I would here beg to acknowledge my indebtedness to the families of William Flett, Esq., and Hon. Robert Hamilton, of the Hudson's Bay Company, for their kind hospitality during my stay at the Fort. I left Winnipeg, by stage, on the 5th of November, and, travelling *via* St. Paul and Chicago, arrived in Montreal on the 15th of the same month. The whole distance which I had gone over during my absence, including my journeys to and from Fort Garry, amounts to upwards of 5,200 miles; and in addition to this, after leaving Fort Garry, my assistants, unaccompanied by myself, made journeys on business of the survey, amounting to over 1,000 miles more.

THE SUPERFICIAL GEOLOGY OF THE NORTH-WEST TERRITORY.

In the prairie regions of the north-west territory, loose deposits of Post-Tertiary age cover the surface of the country almost universally, and they are usually of considerable depth. There are immense areas having the same general elevation, or without very great or sudden changes of level, yet, with the exception of the first prairie steppe, there is a remarkable scarcity, or perhaps absence, of extensive stratified deposits of sands and clays, such as occur in the Provinces of Ontario and Quebec. The bulk of the superficial deposits is of the nature of boulder-clay or unmodified drift, which is spread alike over the older rocks from the lowest to the highest levels. In those portions of the territory which have come under my own observation, the materials of the drift appear to be made

Scarcity of stratified deposits.

Composition of drift.

up of the debris of the rocks existing *in situ* immediately beneath or a short distance to the north-eastward, together with a greater or less proportion derived from those lying further off in the same direction. As a rule, the softer or more clayey part has come from the underlying strata, while the harder pebbles and boulders are the furthest transported, still, in washing out the finer ingredients it is always found that much of the incorporated sand and gravel is of foreign origin. The nature of the transported boulders and pebbles varies somewhat in different localities, and by a careful study and comparison of the proportions in which the different kinds occur, (if made in a sufficient number of places throughout these regions) we might ascertain more precisely the direction whence the drift at any locality had come, provided the geographical distribution of the older rocks, bordering the prairies, were known. Such knowledge would be useful in tracing up anything of economic value which might be found in the drift, such as gold or the ores of other metals. In reference to the composition of the drift, as far as my own observations have extended, more than half of its bulk, on an average, consists of local material. On the first and second prairie steppes the most abundant constituent of the transported portion is Laurentian gneiss, while the remainder is made up of light-colored unfossiliferous limestones, supposed to be Silurian and Devonian, together with a proportion of Huronian schists, which varies in different localities. On the third steppe, however, as stated in my report of last year (page 75), "smooth pebbles of finely granular quartzite predominate. These are mostly white, but some are grey, brown, pink and red, the latter often passing into banded compact sandstone. There are also pebbles of dark fine-grained diorite, light-coloured limestone, and some of dark fine-grained mica schist, and of white translucent quartz, the last mentioned being often rough surfaced." Mr. George M. Dawson, naturalist to the International Boundary Commission, thinks this quartzite drift has come eastward from the foot-hills of the Rocky Mountains, where in the neighbourhood of the line (latitude 49°), he found unfossiliferous rocks *in situ*, some of which resemble certain varieties of these quartzite pebbles. I may here mention, that I have received from the Rev. Père Petitot, per J. J. Hargrave, Esq., of Fort Garry, a fragment of white saccharine quartzite from the McKenzie River, exactly like that of the white pebbles of the third steppe, which, as above stated, constitute the predominating variety in the districts which I explored in 1873. In your own report for 1873 (page 57), you state that "by far the larger proportion of the pebbles and boulders in the river at Rocky Mountain House (about latitude

Quartzite pebbles.

Quartzite from McKenzie River.

52° 20′), are composed of hard silicious rocks, and many of them are traversed by cylindrical forms, having all the appearance of the *Scolithus* of the Potsdam formation."

Course of movement of drift.

While the composition of the boulder-clay of the first and second prairie steppes, and also, to some extent, that of the third steppe, as well as the course of the glacial striæ on the hard rocks on the east side of the prairies, would indicate that the drift had been mainly from the north-eastward, the above evidence shows that a large proportion of the transported material on the highest levels has come from the north or west. A part of what is now found in some localities may have been moved first in one direction and afterwards in another, whilst the bulk of the older drift, including, perhaps, even that on the third steppe, has probably come from points between north and east. The quartzite pebbles of the third steppe were all thoroughly water-worn, and appeared to me to be most abundant on and near the surface. The upper 200 feet or thereabouts, of the south bank of the South Saskatchewan at the Red Ochre Hills, consists of clayey drift, in which boulders of Laurentian gneiss occur, while the surfaces of these hills are strewn with smooth quartzite gravel and cobble-stones. At the distance of 150 miles to the south-eastward, between the Dirt Hills and the Woody Mountain, the proportion of quartzite gravel on the third steppe has diminished considerably, and Laurentian boulders have become very numerous on the surface.

Huronian *debris*.

Between Fort Garry and Fort Ellice, as stated last year, Huronian boulders are scarce, and in this interval, I have not observed many pebbles derived from this formation among the finer materials of the boulder clay. Both boulders and pebbles from rocks of this formation are, however conspicuous for their abundance in the drift in the banks of the Assineboine for some miles above and below the junction of the Shell River, and in the banks of the Calling River in the neighbourhood of the Fishing Lakes. They were also noticeable on the surface all the way from these lakes to the Touchwood Hills. Surface boulders are extremely abundant on the southern and western sides of the gravelly and sandy tract south-west of Fort Ellice, about the head waters of the Calling River, and in many places on the high ground of the third steppe, which I have just referred to, between the Dirt Hills and the Woody Mountains. By far the greater number of the boulders in all these localities consist of Laurentian gneiss. Many of them are angular, although the majority are pretty well rounded. In each of the above districts, the boulders are

Surface boulders abound.

so numerous, over considerable areas, that a man might walk upon them in any direction without touching the ground.

Limestone drift of Lake of the Woods.

In going from the North-west Angle of the Lake of the Woods towards Fort Garry, the road for long distances, runs upon low ridges of limestone-gravel between swamps, until reaching the drier ground between the White Mouth River and Oak Point, and in this interval, boulders and pebbles of light-coloured limestone are very common. According to Dr. Bigsby and Mr. George M. Dawson, gravel and fragments (often large) of the same rock are strewn abundantly on the shores around the south-western part of Lake of the Woods. In the northern part of Lake of the Woods, and in the region of the Winnipeg and English Rivers, limestone fragments are extremely rare, so that their sudden appearance in such abundance to the west and south of the North-west Angle would appear to indicate the occurrence of this rock *in situ* in the immediate neighbourhood. Small knolls and ridges of gneiss were, however, observed in many places along the road from the North-west Angle for thirty miles, or nearly to the Birch River, and Mr. Dawson has found gneiss on the point on the south shore between the mouth of Rainy River and the south-west bay of the Lake of the Woods.

Directions of glacial striæ.

The glacial striæ on the east side of Lake Winnipeg, between the Dog's Head and Fort Alexander, run south 25° to 30° west (magnetic), and in the whole of the great region between Lake Winnipeg and Lake Superior, and thence northward to the Albany River, the general direction of the striæ is south-westward. Still, I have noticed occasional exceptions, and in the Thunder Bay and Lake Nipigon regions, I have observed one set of grooves having a south-south-eastward direction. Should such a course have prevailed in the Winnipeg basin, in reference either to ice or ocean currents, towards the close of the drift period, all the limestone debris which we now observe to the west and south of the Lake of the Woods might easily have come from the bed or west side of Lake Winnipeg. It is worthy of note in this connection, that this is the general course of Lake Winnipeg itself, and also of all the streams between the Red and Winnipeg Rivers. I might also mention that limestone debris is very abundant on the banks of the Rainy River, along which the only rocks known to occur *in situ* are of Laurentian and Huronian age. The following list of the directions of the glacial striæ, noted by myself in 1872 and 1873, in part of the country drained by the Winnipeg River, may prove of interest in connection with this subject. The bearings are all magnetic.

1. In several places around Wesaxino Lake, (next large lake S. of Sturgeon Lake)	S. 10° to 20° W.
2. On canoe-route followed in 1872, two miles south of Sturgeon Lake	S. 40° W.
3. South-east shore of Sturgeon Lake, seven miles from south-western extremity	S. 20° W.
4. South-east shore of Sturgeon Lake, six and a half miles from south-western extremity	S. 15° W.
5. North end of Hut Lake	S. 25° W.
6. East end Kitchi-Sagi, or Big-Inlet Lake	S. 15° W.
7. Inlet of Jarvis Lake	S. 10° W.
8. Minnietakie Falls	S. 35° W.
9. Island on Minnietakie Lake, four miles south-west of Abram's Chute.	S. 45° W.
10. Abram's Chute, at outlet of Minnietakie Lake	S. 25° W.
11. Pelican Falls	S. 45° W.
12. "Stormy" Point, on N. side of Lonely Lake, twenty-four miles from its outlet	S. 60° W.
13. "Shanty" Narrows, Lonely Lake, fifteen miles from outlet	West.
14. Outlet of Lonely Lake	S. 75° W.
15. Island in Maynard's Lake, English River	S. 20° W.
16. Narrows between Tide Lake and Ball's Lake, English River	S. 70° W.
17. Outlet of Indian Lake, English River.	S. 30° W.
18. Inlet of Lount's Lake, English River.	S. 40° W.
19. Outlet of Lount's Lake, English River	S. 45° W.
20. Entrance to south arm of Separation Lake, English River	S. 50° W.
21. Winnipeg River, at entrance to Sandy Bay	S. 45° W.

22. North-west shore of Lake of the Woods, seven miles from Rat Portage	S. 25° W.
23. Manitou Minis, in Lake of the Woods, fifteen miles S.W. of Rat Portage.	S. 20° to 30° W.
24. "Hone" Point, in Lake of the Woods, eighteen miles S.W. of Rat Portage	S. 45° W.
25. "Dead Oaks" Point, in Lake of the Woods, twenty miles S.W. of Rat Portage	S. 40° W.
26. Island in Lake of the Woods, about twenty-five miles S.E. of entrance to North-West Angle	S. 25° W.

Aspects of surface of country.

In the three prairie steppes there is a marked difference in the general aspect of the surface of the country and in the character of the river-valleys. On the first steppe, the surface is usually level or undulating in long gentle sweeps, and the beds of the principal streams do not probably average more than thirty feet below the level of the surrounding country. On the second steppe the surface is rolling, and the river-valleys are usually from 150 to 200 feet in depth, while on the third, the hills are on a larger scale, and either closely crowded together, or they rise here and there to considerable heights overlooking less rugged tracts. The principal river-valleys on this steppe are from 200 to 500 feet deep. The "coulees," as they are termed, from a curious feature of the third prairie steppe. These are valleys or ravines with steep sides, often 100 feet or more in depth, which terminate or close in rather abruptly, often at both ends, forming a long trough-like depression; or one of the extremities of the coulee may open into the valley of a regular water-course. The coulees sometimes run for miles, and are either quite dry or hold ponds of bitter water, which evaporate in the summer and leave thin incrustations of snow-white alkaline salts.

"Coulees."

Depths of river valleys.

The average depth of the river-valleys of the first and second prairie steppes is not affected by the general descent of the country through which they run. From the Little Boggy Creek to the Arrow River, the Assineboine must fall four or five hundred feet, yet the banks of the valley maintain the same general height and the same character throughout the whole distance. Similarly, the fall in the Calling River from the Sand-Hills Lake to its junction with the Assineboine, cannot be far from 500 feet, and still its valley-banks have the same average height throughout. The fall in the Red River, from Moorehead to Fort Garry, is upwards of 200 feet; but in the whole of the distance the banks of the river have a nearly uniform height of twenty or thirty feet.

Antiquity of valleys.

The class of valleys, of which those of the Calling River, the Upper Assineboine and its branches, and the Rapid or Little Saskatchewan River may be taken as examples, are evidently more ancient than the streams at present flowing through them. The latter appear to exert but a feeble influence in enlarging them. The former windings of the streams in these valleys have, in many places, been thrown, from time to time, into new channels, leaving the old ones in the form of long narrow semicircular and crescent-shaped ponds which have become more or less filled up according to their antiquity. Jams of driftwood, beaver-dams and the breaking through of narrow necks between long loops of the stream have been among the principal causes of the shifting of the channels. Beyond such slight changes as these, the present rivers and brooks appear to have but little effect in modifying the valleys. The conical hills, of all sizes, which in some parts of these valleys, rise one above another, producing the "hummocky" appearance in the banks which I referred to last year in the case of the Calling River (page 72), have, no doubt, been formed by repeated land-slides, probably at a time when the foot of the main bank on either side was washed by water. The gradual retrocession of the water (which would constantly have the form of a narrow bay) down a valley like this would bring every part of the foot of the banks successively under its influence, and it might thus have produced the uniform character which we now observe. That the cause which produced this character has now ceased to operate, is evident from the permanent and weather-beaten aspect of the banks and hummocks and the rarity of modern land-slides.

Relations of valleys to rock-formations.

The great valleys of the third steppe cut entirely through the drift and far down into the underlying Tertiary and Cretaceous rocks; those of the second steppe appear to correspond in a general way with the depth of the drift, while on the lowest steppe, the streams have merely cut through the modified deposits resting upon the drift, which latter is occasionally exposed at low-water at the foot of the banks, or in the bed of the stream at swift places and rapids. These streams have the same relation to the modified deposits referred to, as is borne by the present channels of such streams as the Calling and Upper Assineboine Rivers, to the laminated alluvial clay and silt, lying in the bottom of their more ancient valleys. Valleys, such as those last mentioned, may have been

Mode of formation of valleys.

excavated in the drift along the course of streams which once flowed over its surface in the following manner:—If the country were being gradually submerged, the channel of a stream of this kind, already worn to a greater or less depth in the drift, would naturally be deepened and enlarged by the continued wearing action of the river itself, and the transporting agency of the water at its mouth. The mouth of the stream would be moved gradually up, as the water encroached upon the land, until, if the depression were sufficient, the whole of the former river would be submerged. Meantime, the recently formed and submerged valley might be filled up with softer materials. On the emergence of the land, the valley would be partially or entirely cleared out again, and further enlarged by the sliding down and washing away of its banks in the manner I have just described. Terraces, more or less distinctly marked, may be observed in places along the sides of any of the valleys of this class. They are well seen, especially about the lowermost of the Fishing or Qu' Appelle Lakes. The amount of material which has been removed, to form these valleys, has been enormous, and could not have been carried away by the unaided action of the small streams flowing through them at the present time. This material may now be spread out upon the lower levels, forming the clay, through which the Red River has cut its channel, as well as the fertile soil of the first prairie steppe. The ridges of hard boulder-clay, which occur in the river-valleys of the second steppe, present an additional argument against the supposition that these valleys might have been formed under the existing condition of things. Although the thickness of the drift appears to correspond, in a general way, with the depth of these valleys, I have observed one exception in the case of the Calling River, about thirty miles west of Fort Ellice, where the marls and soft shales of the Cretaceous period are exposed in both banks nearly to the top. This fact, however, would not interfere with the formation of the valley in the manner above described; these shales and marls being fully as soft as the stiff boulder-clay of the rest of the valley. The land was probably sufficiently submerged to carry the water over the greater part of the third prairie steppe, and its emergence appears to have been tolerably rapid; washing out the boulders and leaving the tops and sides of the hills, as well as the valleys between them, covered alike, with a gravelly coating, which forms the sub-soil almost universally on the third and second steppes.

Deposits of first prairie steppe.

The stratified clay, silt, sand and gravel of the Red River and the lower Assineboine vary in thickness from almost nothing to eighty or ninety feet, so far as known; and a variable thickness of boulder-clay is interposed between these deposits and the older rocks, which lie beneath them all. During the past summer a number of new wells have been dug or bored through these deposits in the city of Winnipeg and in various parts of the settlements of Manitoba. The Hon. Donald McDonald of Toronto had collected a number of interesting notes in reference to these wells, and he informed me that they seldom failed to furnish water at depths not exceeding seventy or eighty feet. After passing through the black loam at the surface, which varies from one to six feet in depth, light grey, drab, and more frequently yellowish, somewhat sandy clays were passed through, when hard pebbly and bouldery clay, or, in some cases possibly, solid rock was reached. The water of these wells is generally good, but in some instances it is too brackish for household purposes. Some of the superficial clays around the city of Winnipeg have been found within the last two years to make, under proper skill, "white" bricks of an excellent quality, resembling those of Toronto. The principal buildings in the city are now being constructed of these bricks. In other places around Winnipeg, red bricks have been made from clay dug near the surface. In the district between the south end of Manitoba Lake and the Assineboine River (east of a line drawn from Prairie Portage to Westbourne), all the wells have passed through sand, and I am not aware of any of them which required to be dug to a greater depth than about twenty feet, in order to find good water. A short distance to the southwest, however, or around Burnside, in Township 12, Range VIII., west, there is a remarkable area in which all attempts to obtain water by sinking wells have proved failures. Several of these had been dug to depths varying from thirty to eighty feet, mostly through bluish clay. In sinking through the surface deposits on Mr. Kenneth McKenzie's farm, preparatory to boring in the harder rocks beneath, Mr. Alexander McDonald found the blue clay to be seventy feet in depth, and to be succeeded by eighteen feet of sand gravel and clay, below which he struck a light-colored limestone.

Brick clays.

Area without water.

Surface boulders.

On the surface of the first prairie steppe, boulders are rare and of small size. In reference to the deposits of stratified sands, which are exposed in banks from sixty to one hundred feet in height along the lower part of the Winnipeg River and around the south-eastern shore of Lake Winnipeg, you observe, in your report for 1872, page 18, that the large boulders found with the sand, rest upon the surface of these deposits, and are not imbedded in them, showing that they, as well as the small boulders scattered on the surface of the lower prairies, have been dropped from floating ice, after these sands, as well as the stratified clays, &c., of the first prairie steppe had been deposited in comparatively tranquil waters. Near Oak Point, on the road from Fort Garry to the Lake of the Woods, the boundary between the smooth open prairie and the higher wooded region to the eastward of it is very sharply defined and conspicuous, resembling the shore of a great lake. The surface of the prairie is level, free from boulders, and has a loamy black soil, while that of the adjoining wooded region is undulating, has a comparatively poor and light-colored soil, and is studded in some parts with boulders.

Eastern edge of prairie.

There is ample proof that the Winnipeg basin has been filled with water to the foot of the second prairie steppe in recent geological times, but very little positive evidence has yet been found to show whether this was fresh or salt. The highest of the sand deposits, containing fresh water shells, between the south end of Lake Manitoba and the Assineboine River, have an elevation of probably less than fifty feet above the former, while the long parallel gravel ridges of the Beautiful Plain region and of township 15, range XV, west, would be from one to two hundred feet higher. The sand ridges and dunes along the Assineboine River, between Prairie Portage and the junction of the Souris, have different elevations, but they all probably come within the above limits. The summit of the long shingle ridge of The Poplars in the Swan River valley, which has been already referred to, I estimate to have an average elevation of about 180 feet above Lake Manitoba, and it appears to belong to the class of deposits now under consideration. I had not an opportunity of examining the Big Ridge, south of Shoal Lake, nor the apparently remarkable ridge in township 11, Range XXIV., west.

Elevations of ridges.

According to the reports of the Canadian Pacific Railway Survey, published last year, the level of Lake Winnipeg above the sea is 710 feet, of St. Martin's Lake 737 feet, of Lake Manitoba 752 feet, of Lake Winnipegosis and Cedar Lake 770 feet, and of Lake of the Woods 1,042 feet. These elevations have been found from a series of spirit-levels carried all the way from the sea. The apparent absence of fossils in most of the modified post-tertiary deposits of the first prairie steppe, is an argument in favor of supposing them to be of fresh-water origin, since fresh-water shells are liable to become obliterated in loose sand and gravel, while those of marine origin are more enduring. Besides, mollusca of all kinds are scarce in large cold northern lakes. On the other hand, the fact of the existence of such large boulders on top of the sandy deposits around the south-eastern part

Elevations of lakes.

Fresh or salt water.

of Lake Winnipeg points, perhaps, to a former communication with the sea.

Floods of the Red River.

The Red River, in different parts of its course, occasionally floods its banks in the spring, and covers the prairies for miles on either side with water, which deposits a certain amount of silt, and leaves behind more or less drift-wood and vegetable refuse upon the surface. The laminated clayey deposits of the Red River valley may have been wholly or partly formed in this manner. In digging wells in the city of Winnipeg, it is said that wood, bark and leaves are sometimes met with.

Margins of White Mud River.

On either side of the White Mud River the ground is higher just above the bank than at the distance of a few chains away from it. In the neighbourhood of Westbourne, the surface of this raised strip of land is covered with stones and small boulders, which are absent on the lower ground. The bed of the river is also full of stones and boulders. The river is low when it freezes up in the autumn, and many stones become fixed to the ice, which is liable to be carried over the top of the banks during the spring freshet. In this way, the stones which I have referred to, have probably been strewn, in former years, where we now see them.

Bones of mammals.

In the second prairie steppe, bones of the buffalo are often seen in river-banks, buried under a few feet of silt; and the remains of the elk are occasionally met with in similar situations. The rumours of the discovery of some mammoth's bones in one of the banks of Shell River, which have long been current in the country, are referred to in Mr. Spencer's report. In my report for last year (page 73), I mentioned a rumour in regard to large bones at the Sand-Hills Lake, and also at the Cypress Hills (page 74). On the west side of the Assineboine River, at the distance of five or six miles in a straight line above the Shell River, or ten miles following the stream, I found an arrow-head, tolerably well-formed, from a reddish cherty rock, lying among the stones, sand and gravel on a naked bank of drift about fifteen feet high, overlooking the river.

Arrow head in drift.

Formation of prairies.

As bearing upon the questions in reference to the formation of prairies, and the causes which prevent them from becoming covered with trees, I may mention the fact that on the second steppe, at least, the character of the soil, locally, has an important relation to the wooded or open condition, which we find prevailing at the present time. In this region, the existence of trees appears to depend upon the capacity of the soil for receiving and retaining the proper amount of moisture. The clayey loam of the Little Touch-wood Hills, supports a continuous, thick and strong growth of trees, whereas the gravelly and sandy soil of the

Relation of soil to prairie or forest.

surrounding country produces little more than scattered clumps of aspens and willows. On entering the Five-mile Woods, in the Swan River valley, the change from a light sandy to a stiff-clayey soil is at once observable. The belt of heavy timber which I passed through between the Big Boggy Creek and the upper part of the Shell River, corresponds with a stronger soil; and generally, in the Duck Mountain region, where the country presents a mixture of prairie openings and woods, the former coincide with the lighter, and the latter with the stronger soils. Another instance of a thick growth of trees upon a clayey area is found in the Bad Woods near the western boundary of Manitoba, on the middle trail to Fort Ellice, and many more examples might be mentioned. Conversely, the drier sand and gravel areas are usually devoid of timber, although the depressions among sand dunes and ridges seem to be the favorite *habitat* of the scrubby-oak. Near Fort Ellice, the bouldery-clay of Beaver Creek, and of the north-facing slope of the Calling River, are thickly covered with poplars, while the gravelly and sandy area above the banks, stretching for some twenty miles to the west, and fifty to the north, is destitute of timber, except here and there, where some local change allows the trees to take root. The gravelly and sandy plain on the north side of Fort Pelly, and the set of open ridges, of which Beautiful Plain is one, are similar examples. The geological history of the prairies of the lowest steppe, has probably been different from that of the others; yet, even here, examples of conditions resembling the foregoing, are not wanting. On both the second and third steppes, the northern slopes of valleys are often wooded, while those facing southward are quite bare. The banks of the Calling River form a good example of these conditions, which are, no doubt, due to the influence of the sun; first, in melting away the snow in the early spring, and afterwards, in parching the bank during the summer, while, on the northward slope, sufficient moisture is retained to admit of the growth of trees. Although the surface of the barren treeless district along the foot of the Coteau, from near the elbow of the South Saskatchewan to the head-waters of the Souris River, consists of clay instead of sand, the absence of timber is here also, no doubt, due to the same cause—namely, want of sufficient moisture. The surface of the ground is here formed of the almost undisturbed stiff clay or marl of the Tertiary formation, which resists the water, and is incapable of retaining, throughout the hot, dry summer, any moisture which might enter it during the winter or spring. As a consequence, the ground has become deeply fissured and baked as hard as unburnt brick.

Treeless areas.

Woods on north facing slopes.

Treeless clay district.

Circular ponds.

Anyone who has travelled over the second and third prairie steppes must have observed that the outline of each of the ponds, which exist in almost countless numbers, is generally rounded, or almost circular, no matter what may be the shape of the earth-hills surrounding it; and also, that if there be any boulders in its basin, they are usually arranged in the form of a ring around its margin. These basins are uniformly deepest in the centre, and they shoal equally to the edge all round. All of these phenomena may, I think, be accounted for in the following manner:—Although nearly all the ponds dry up in the summer time, most of them contain more or less water in the autumn, and any which may now be dry almost all the year round, no doubt held water in former times. As these ponds gradually freeze to the bottom, the water and mud under the ice in the deepest part remain longest unfrozen. The intense frost later on in the winter would naturally expand the first formed ice, forcing it and its incorporated boulders and earth in all directions from the centre towards the circumference. (I may here mention that this phenomenon is reported as having occurred during the present unusually cold winter in Cayuga Lake, in the State of New York.) Towards the spring, the alternate freezing and thawing, combined with the evaporation from the surface, which must be rapid in the dry climate of the North-West Territory would tend to bring the boulders to the top of the ice. While all the loss would be at the surface and towards the edges, any addition at this season would be at the bottom and towards the centre. As a result, the ice would swell relatively in the centre, as glaciers do in summer, and there would be a tendency for the boulders to roll as well as to be pushed towards the margin. The amount of movement each year might be very small, still, if we allow a sufficient length of time to have elapsed, the above operations would be sufficient to account, not only for the accumulation of the boulders around the edges of the ponds, but also for the regular basin-shaped form of their bottoms and their rounded outlines; for this force would, at the same time, tend to deepen them in their centres, wear down inequalities in their beds, round off points, and fill up bays. When such ponds as these are filled by the melting of the snow or by the rains in spring, before the ice has thawed away, the latter becomes detached all round, and is made to rotate more or less by the wind. This would aid in giving the circular form to the ponds. The absence of logs, trees and roots about these ponds would also facilitate the action of the above forces.

Rings of boulders.

Supposed mode of formation.

Ice-formed beaches and islets.

Another effect of the recent action of ice in the North-West Territory may be witnessed in the islets formed by boulders and earth, which occur in the larger lakes and in the long dyke-shaped ridges of the same materials, which are often met with around their shores. In Mr. Spencer's report, reference is made to such ice-formed beaches on Lake Winnipegosis, and their remarkable prevalence around this lake is noticed in Archbishop Tache's "Sketch of the North-West of America." I have observed them on Lakes Manitoba and Winnipeg, but more particularly on St. Martin's Lake. Here, the ice, either by expanding while fixed, or by shoving, under the pressure of the wind when afloat, has formed numerous islets on the shoals; and around the edges of many of them, it has piled a wall of boulders to the height of six or eight feet. At the extremity of each of several points, a semi-circular space is surrounded, on the lake side, with a similar wall of boulders, mixed with gravel and earth, which shewed, in some cases, the fresh work of the ice of the previous winter or spring. Some of the long narrow bouldery points and reefs of this lake are probably due, however, to much more ancient glacial action.

ON THE DIMINUTION OF WATER IN THE NORTH-WEST TERRITORY IN RECENT TIMES.

Mr. Selwyn's remarks.

In the journal of your expedition from Rat Creek to Rocky Mountain House, you refer to the drying up of the country. Speaking of the neighbourhood of the Pheasant Hills (Report for 1873-4, page 27,) you note: "Lakes and lake-basins more abundant, the water in many of them slightly brackish. They appear all to be gradually diminishing in size and drying up. This, McDonald tells me, has been going on steadily for several years. He says, that what were large lakes are now small ponds, and all the lesser ones are quite dry and their beds overgrown with grass and weeds." Further on, you remark that this drying up of the country "is generally supposed to be connected with the gradual destruction of the forests over large areas by fire diminishing the rainfall." The presence of trees has not only a general, but in the region under consideration, even a local effect on the rain-fall. Between the true forest, lying to the north and east of the Assineboine River and the true prairie, to the south of the Calling River and the north branch of the Saskatchewan, there is a belt of an intermediate character, embracing much of the finest land of the "fertile belt." In the true prairie region there is very little water. In some parts of it, one may travel for days in any direction without meeting a stream. Water is much more plentiful in the half-wooded region; while the quantity which flows away, in the

Effect of trees on rainfall.

form of rivers or brooks, from a given area in the forest country, is even very much greater than from an equal extent of the former. The amount of water which is discharged from the true prairie region, within Canadian Territory, must be very small. During the summer the South Saskatchewan and its branches appear to loose rather than gain in volume as they traverse the plains.

Dry beaver dams.

The encroachment of the prairie upon the wooded region, owing to the destruction of the forests by fire, would also diminish the amount of rain-fall in the timbered country immediately adjoining. I have already mentioned the extensive dry beaver-dams in the Swan River Valley. Referring to this subject, Archbishop Taché, in his "Sketch of the North-West of America," says: "It is true that clearing land will render it salubrious by a natural process. Proof of it is seen in prairie land recovered from forest where there are depressions—old swamp ground—without the least moisture; and even on perfectly dried up new prairie land, beaver-dams are to be seen—certain evidence of the existence of lakes or ponds at the time when the plain was wooded." I have also noticed these ancient dry beaver-dams in the southern part of the Riding Mountains, on the table lands of the Duck Mountains, and in dry valleys in various places in the prairie between the Little Saskatchewan, or Rapid River, and Fort Ellice, and also about the head-waters of the Calling River.

Muskrat's holes.

In the ponds in those parts of the second and third steppes, which I have visited, muskrats are now seldom to be seen, although they are said to have been quite plentiful in many of them within the recollection of men who are still active hunters. Around numbers of these ponds, I have seen horizontal rows of their dry and deserted holes, at levels considerably above those now reached by the surface of such of them as still contain some water, and also around others which seem to be now permanently dry.

Overgrown pond basins.

On the second steppe the circular ponds and pond-basins, to which I have already referred, are usually surrounded by a ring of willow bushes growing just above what is now, or has been formerly, high-water mark. The whole of the space thus enclosed is generally overgrown with reeds and sedges; in addition to which, there are often grasses and other plants which partake of a dry-land character. A total drying up or marked diminution has evidently taken place in the streams which flowed in some of the larger valleys. Examples of this may be found in the Big Dry Valley and in Snake Creek east of Fort Ellice, and also in the upper part of the Calling River. Parts of the last mentioned river which, fifteen

Diminution of Streams.

years ago, were stated by explorers to be navigable for canoes, are now silted up, and the continuity of the stream is broken by portions of the old bed which are quite dry in summer. In some sections, the channel is becoming rapidly obliterated, and long stretches of it are marked only by a winding row of tall reeds.

Island at Prairie Portage.

At Prairie Portage, the island is surrounded by a marsh of nearly equal width all round—evidently an old channel of the Assineboine River. Six or seven years ago, the inhabitants could dip water from this marsh nearly all the year round, whereas, now, most of its surface has become dry, and wells require to be dug in it to reach the water.

Watering places.

Travellers who have been accustomed to cross the prairies from year to year, notice a growing scarcity of water at the camping places along the trails. The watering ponds which hold out the longest, must be fed by springs, as otherwise they could not withstand the rapid evaporation during a long drought; and besides, some of them are on higher ground than the surrounding prairie. The permanent "water-holes" are often quite small and marked by clumps of willows, which, however, differ in no way from those surrounding scores of dry pond-basins in the neighbourhood. I have been informed by old prairie travellers, that in the Battle River country, in the driest seasons, they do not seek for water in the valleys or the lowest depressions, but among the willow-clumps on the high grounds.

Red River floods.

The flooding of the valley of the Red River on the melting of the snow in spring, appears to be growing less frequent and troublesome. Mr. John Fraser, of Kildonan, one of the oldest native white men in the Red River Settlement, informed me that in the spring of 1826 the water rose five feet over the ground on which the city of Winnipeg is now built; that in the flood of 1852 it covered the same spot to a depth of only two and a half feet, and in that of 1861, the water merely rose to the level of the surface of the ground.

Burning of forests.

Besides such facts as the foregoing, the general belief of the oldest inhabitants and travellers, and the traditions of the Indians, all point in the same direction; and there is no doubt the gradual diminution of the water supply of the "fertile belt" is a matter for serious consideration. Your remarks on the destruction of the forests by fire, between Red River and the Rocky Mountains (Report for 1873-74, pages 58 and 59) are corroborated by all that I could hear on the subject. The rapidity with which some tracts between Prairie Portage and Fort Ellice, were stated to me to have been converted from forest to prairie is almost incredible. The aspens of that region burn much more readily than does the wood of the same tree in Ontario and Quebec, and the portions which escape total destruction by fire, rot and disappear in the course of one or two years.

Prairie fires.

In former times, before prairie travelling had become so general or of so promiscuous a nature, much care was taken to prevent fires. In view of the great importance of this subject to the prosperity of the country, it would be advisable, as soon as an efficient means for governing the Saskatchewan country shall have been established, that there should be some legislation to prevent the careless or wanton setting fire to the prairies, and the good sense and intelligence of the inhabitants and of travellers should be appealed to for the same purpose.

I have the honor to be,
Sir,
Your obedient servant,
ROBERT BELL.

REPORT

ON THE

COUNTRY BETWEEN THE UPPER ASSINEBOINE RIVER

AND

LAKES WINNIPEGOSIS AND MANITOBA,

BY

JOSEPH WILLIAM SPENCER, BAC. APP. SC.

OFFICE OF THE GEOLOGICAL SURVEY,
MONTREAL, *March* 13*th*, 1875.

ROBT. BELL, ESQ., C.E., F.G.S.

SIR,—I have now completed the maps of the regions which you detailed me to explore as your assistant while in the North-west Territory last season; also the chemical analyses of some specimens collected in the course of these explorations; and I would now beg you to submit them, together with the following report, to the Director of the Survey.

Your obedient servant,
JOSEPH WILLIAM SPENCER.

Journey. Having received your instructions to proceed to Winnipeg, I started about the middle of last May, going by way of Lakes Huron and Superior as far as Duluth. At Thunder Bay I had an opportunity of examining several of the mining locations. From Duluth I went by rail to Fargo, and thence by Red River steamer to Winnipeg. After having travelled along with you from Winnipeg to a point about fifty miles north of Fort Ellice, I proceeded, in compliance with your orders, to make an exploration of Shell River and the adjacent parts of the Assineboine River; being assisted by Mr. William Hagar and one or two workmen. I chose a site near the junction of the two rivers for a camp, and proceeded to make the explorations on foot, which was the only practicable way.

Assineboine valley.

The valley of the Assineboine, adjacent to that of the Shell River, is about a mile wide, and some 200 feet deep. The alluvial flat at the bottom of the valley is three-quarters of a mile wide, and the banks rise steeply on either side. Through this level flat the river pursues a meandering course from side to side, occasionally leaping a small rapid caused by the obstruction of Laurentian boulders. Twenty miles farther up, the valley is nearly three miles wide, but at this place in the bottom, and following the valley longitudinally, there are four or five series of hills rising irregularly, one above the other, till the highest reaches nearly to the level of the plain above. Between these hills there are small deep valleys. The western bank is often strewn with gravel and boulders, while the flats below are nearly free from them, excepting in places along the bed of the river. The sides of the valley are often deeply gorged, but the ravines do not extend to any great distance back from the valley. Many of them appear to have been cut out by the waters from springs. These springs usually hold a considerable quantity of iron in solution, and I observed several places where yellow ochre was being deposited around them. In several localities on the banks of the Assineboine, extensive landslides are to be met with, sometimes showing stratified deposits of clay or sand. The general course of the Assineboine valley at the influx of the Shell River is nearly south, but above it has a more westerly direction.

Shell River.

I explored the Shell River valley upward for thirty miles, and Mr. Hagar continued the exploration for ten miles farther. Along the upper part of this distance the country on either side has usually a rolling prairie character, while in the lower portion the river flows in a valley nearly as wide and deep as that of the Assineboine. The general course is nearly from the north. At the bends of the valley, the river usually winds its way to the outer side, and on the inner side of the curve there is left a terrace, or series of terraces, rising from the alluvial flat to the plain above. The country is generally wooded, except here and there where fires have swept over small areas. The Shell River is much more rapid than the Assineboine, and the sides of the valley are much more deeply gorged than those of the latter river. At the landslides along the Shell River, I observed a few stratified deposits, but they generally showed only a heterogeneous mixture of gravelly earth with boulders. The bottom of the river often abounds with fresh-water mollusca, and hence, perhaps, the origin of the name of the stream. Returning to Fort Pelly, I received your instructions for the rest of the season, in compliance with which I proceeded to explore Swan River.

The Assineboine valley in the vicinity of Fort Pelly is not sharply defined, as it is further south, by a limited breadth and steep escarpments. North-east of Fort Pelly the land gradually rises for six or eight miles to the water-shed, between the Assineboine and the Swan River, and then descends to the latter. **Fort Pelly.**

From the Swan River Crossing (where we started to descend the river) the distance to Swan Lake, by the stream, is 130 miles, although by the trail it is only about half as great. In descending the river I noted no less than 446 rapids. These are generally caused by the descent of the water over Laurentian boulders, but sometimes over the country-rock. The whole descent of the river, from a point abreast of Thunder Hill, was estimated at from 450 to 500 feet, and Thunder Hill rises 300 to 350 feet over this point. The average width of the river is about 100 feet, but sometimes it becomes very much wider, enclosing picturesque islands, while in other places it is quite narrow, but deep. The river for the last thirty-five miles before reaching Swan Lake is free from rapids and is navigable for boats drawing two feet of water. In the spring of the year the Hudson's Bay Company send down some of the returns of their inland trade in flat boats, but of course these cannot return. Swan River enters the lake of the same name through a swampy projection of land, extending several miles into the lake. Indeed, all the country for some distance west of this lake is low, but it is generally wooded. **Swan River.**

Thunder Hill is an isolated elevation situated about four miles north-westward of Swan River, and about ten miles below the Crossing. It rises from 200 to 250 feet above the plain, which gradually slopes up from the river. The hill slopes gently to the north-westward, while to the south-eastward there is an abrupt escarpment broken by successive landslides, which are now separated from each other by small valleys. Near the summit the landslides have exposed some calcareo-arenaceous shales, holding fossils of Cretaceous age. At the base of Thunder Hill I noticed several depressions, almost round, measuring from sixty to 200 feet in diameter, and having a depth of twenty feet or more. Some of them contained water, while others were quite dry. **Thunder Hill.**

Sander's River is a branch of Swan River, flowing from the south, and emptying itself into the latter about fifty miles from its mouth. The country through which it passes is similar to the Swan River valley. One day was devoted to the exploration of this branch, and eight or ten miles of its course were examined. Pieces of lignite were found in the bed of the stream, and afterwards along the Swan River, below its influx. After I arrived at Shoal River House, I was informed by a half-breed **Sander's River.** **Lignite.**

that the lignite (called coal) was found in beds from a few inches to two feet in thickness on Sander's River, a few miles above the point I had reached.

an Lake.

e-formed aches.

Swan Lake is about twenty miles in length. Besides the Swan River, it receives two or three smaller streams. The shores are all low and swampy, except at a few points which are made up of gneiss boulders and slabs of limestone. On one of these points in particular, an ice-formed beach occurs, on which boulders, weighing from half a ton to twenty tons, have been piled up with as much apparent ease as if they had been small pebbles. The lake contains several islands, on which the country rocks are exposed. These consist of limestones, and are best seen on two of the largest islands situated in the northern part of the lake, viz., Warren and Lafavorita Islands. The whole lake is very shallow, not averaging more than six feet in depth. The bottom consists of soft loose silt..

oal River.

Shoal River discharges Swan Lake into Lake Winnipegosis. The Hudson's Bay Company's post, Shoal River House, is situated at the outlet of Swan Lake. Shoal River is only from two to four feet deep, and has a width of from 150 to 250 feet. The banks are low on both sides. The current is of considerable velocity, the fall being about thirty feet in its course of eight miles. It empties itself into the southern extremity of Dawson Bay, which forms the north-western part of Lake Winnipegosis.

rcupine
ountain.

mber.

Porcupine Mountain forms a continuation of the chain of high ground which marks the eastern limit of the second of the three great prairie steppes of the North-West Territory. It rises to the height of about 800 feet above Swan Lake. Between the base of the mountain and the lake is a belt of about twelve miles of low ground, consisting of open marshes, or "muskegs," tamarac swamps, &c., while the remainder of the interval is densely wooded with aspen, balsam-poplar, spruce and willow. On the slope of the mountain I saw balsam-poplars six feet in diameter, while in some cases the spruces reached a thickness of nearly four feet. This forest is more ancient looking, and bears fewer evidences of fire than any other that came under my observation in the North-West Territory. The region is little frequented, even by the Indians, being difficult of access. Although fire has not visited the slopes of the mountain or the level ground below for a very great length of time, yet the whole of the forest on the summit was swept away a few years since, and in its place a young growth of poplars has sprung up.

ll River.

The Bell River rises in a lake on the summit of the mountain, and running eastward, cuts its way down the escarpment, forming a series of rapids six or eight miles in length. After reaching the plain below, it turns north-eastward and empties itself into Dawson Bay. The bed of the river is filled with Laurentian boulders, over which the water descends at the rate of about 150 feet per mile. From the foot of the slope my guide and I followed this river to the summit. Along it there are great exposures of shales. Fragments of lignite were picked up along the river, but the beds from which they had been derived were not found.

Lignite.

View of landscape.

Looking back from the point which we reached at the summit of the mountain, the escarpment appears to descend rapidly. It is richly clothed with foliage, and through it the Bell River has cut its valley; the wooded plain stretches from its base, and further on is Swan Lake with its lovely islands. In the far east, Pelican Lake is just visible. To the north-eastward a long sheet of water (Dawson Bay) is seen, while further off the sight is lost in the main waters of Lake Winnipegosis.

Lake Winnepegosis

Lake Winnipegosis is about 100 miles long. Its north-western portion, Dawson Bay (named in honour of Principal Dawson of McGill University) is nearly cut off from the main body of the lake by a long peninsula. This bay has an extreme length of about forty miles, and a breadth varying from five to twenty miles. Both shores are deeply indented with smaller bays. On some of the projecting points, cliffs of a light-coloured limestone occur. There are several islands, on which solid rock is also exposed, as well as many submerged reefs. The highest rocky promontory is Point Wilkins, on the west side of the lake. Most of the points have ice-formed beaches composed entirely of boulders and pebbles, and behind them there are extensive swamps. The north end of the lake is especially low, and the barrier between Winnipegosis and Cedar Lakes is little more than a swamp, from three to five miles across. The greatest elevation of the lowest traverse between them was ascertained by Mr. Bender of the Canadian Pacific Railway Survey, while I was in the neighbourhood, to be forty-four feet over the water at either end (the two lakes being on the same level.) The character of the main body of Lake Winnipegosis is the same as that of Dawson Bay, being studded with islands and reefs. On the east side, between Elm and Gun Points, there is a cliff of limestone of considerable extent. The beaches of almost every point and island are made up of Laurentian boulders and fragments of Devonian limestone, overgrown with trees, behind which are swamps, often of considerable extent, and small lakes.

Beaches.

Cedar Lake.

Beaches.

Salt-works.

I visited the salt works at the south end of Lake Winnipegosis in company with Mr. J. H. Rowan, chief assistant engineer of the Canadian Pacific

Railway, who was returning to Winnipeg, and with whom I arranged for our passage to Oak Point, near the south end of Lake Manitoba. From the salt-works (which will be described further on) I went up Mossy River (the outlet of Dauphin Lake) for a few miles. Here also are limestone exposures. This river has a depth of from two to four feet for a distance of three or four miles from its mouth, where it is about 200 feet wide. An exploratory line of the Canadian Pacific Railway crosses the river three or four miles from its month, and runs north of the Duck Mountain, following up the course of the Swan River Valley. Lake Winnipegosis is of considerable depth, and has clear good water. Owing to sudden and frequent wind-storms, its navigation by small boats is attended with some danger. Lake Winnipegosis is connected with Lake Manitoba by Water-hen River and Lake, both of which are shallow and muddy, and have extensive swamps around them. The river has a total length of twenty-five miles, and descends eighteen feet.

Mossy River.

Water-hen River.

Lake Manitoba.

Lake Manitoba is 130 miles in extreme length. It is a shallow muddy lake with many reefs, which will endanger future navigation, and there are but few good harbours. The portion of the lake south of the Narrows, although considerably wider than that to the north, is still shallower. From Oak Point on this lake to the town of Winnipeg, the distance is about sixty miles, and the trail passes over open prairie, with only here and there a grove of trees.

Winnipeg.

The most noticeable feature between these places is Shoal Lake, forty miles from Winnipeg. It has no outlet, and its waters are consequently saline. The soil in the neighbourhood of the lakes is mixed with much gravel, but when within twenty miles of Winnipeg town it begins to assume a black loamy character. For the first thirty or forty miles south of Lake Manitoba the drift deposits do not appear to cover the country rock to a greater depth than from ten to twenty feet.

GENERAL DESCRIPTION OF THE GEOLOGY OF THE REGION EXPLORED.

Deposits of Neozoic Age.

Junction of formations.

Over large tracts of the North-West Territory it is almost impossible, owing to the rarity of exposures and to the similarity in lithological character of the strata, to tell where the Post Pliocene deposits begin to overlie those of Tertiary age on the one hand, or the deposits of the Tertiary to overlie those of the Cretaceous period on the other. Along parts of the Assineboine and Shell Rivers the valleys are worn out to a depth of 200 feet, and from one to four miles in width. If the rivers which now flow through them have excavated these valleys, the former must be of great antiquity. The valleys are yearly becoming larger by the spring floods bearing away great quantities of material. Everywhere along the river banks there are evidences of former land-slides. Notwithstanding the great depth of the valley, only a few sections of the deposits composing the banks are to be seen. This is owing to the fact that the surface material brought down by the land-slides always covers up the sections, which might otherwise be exposed. Along the Assineboine valley, stratified clays, or weathered shales *in situ*, are sometimes exposed. These shales may possibly belong to the Tertiary series, but I found similar rocks of Cretaceous age at a higher level in Thunder Hill. The deposits of the Shell River valley frequently consist of irregular beds of clay with boulders, while along the alluvial flat of the Assineboine they consist of regularly stratified clays. The summits and sides of the banks of both streams are generally covered with boulders.

River valleys.

Large bones.

In the more recent deposits of the Shell River valley, an Indian is said to have found, a few years ago, some large bones, which were, at the time, sent to Fort Ellice, and afterwards to England. These remains were described to me by a man who had seen them, and also the place whence they came. They appear to have been large enough to have belonged to *Elephas primigenius*, and, in fact, they were called mammoth's bones by the white men of the country.

Rocks in the vicinity of Thunder Hill.

On Thunder Hill, and in many exposures along Swan River, there is but a thin covering of drift over the underlying Cretaceous rocks. Between the foot of the eastern slopes of the Duck and Porcupine mountains and the lakes, the Devonian limestones are covered by only a few feet of drift. The following is a section, in descending order, of these deposits as they occur in the Swan River opposite Thunder Hill:—

	FT.	INS.
Surface soil	3	0
Bed of Laurentian boulders and pebbles	2	0
Stratified coarse sand	0	6
Bed of Laurentian boulders and pebbles	2	0
Stratified coarse sand	0	6
Laminated clay	1	0
Homogeneous clay with pebbles	3	0
	12	0

Fifty miles farther down the river the following beds, in descending order, were observed for a considerable distance along the river:—

	FEET.
Surface soil	6 to 0
Stratified clay in layers 4 to 6 inches thick, variously coloured	4 to 8
Small boulders and gravel	1 to 4

These were underlaid by compact clay, with small boulders and gravel, to an unknown depth. In the Porcupine Mountain, the drift overlies shales, probably of Cretaceous age, which are exposed on Bell River, and elsewhere along the escarpment.

Deposits of Mesozoic Age.

Fossils.

In the region, covered by the title of this report, rocks of the Cretaceous period were observed on Thunder Hill, at a height of nearly 800 feet above Swan Lake; or, at about 1,600 feet above the ocean. Near the summit of this hill, are indurated calcareo-arenaceous shales, containing fragments of selenite. They contain fossils, of which the most abundant are *Inoceramus* and *foraminifera*. Mr. J. F. Whiteaves, who has kindly examined the specimens, finds the latter to be principally *Globigerinæ*.

Cretaceous rocks.

Following the course of the Swan River, below Thunder Hill, there are numerous exposures of Cretaceous rocks. They are mostly shales, with some limestones. The general dip is to the west, at an angle of only about two degrees. The following descending section is the first of undoubted Cretaceous rocks that I observed on the river itself. It occurs a little below Thunder Hill:—

	FEET.
Soft crumbling shales of a drab color	8
Compact shales of the same color	3
Alternate reddish and bluish shales	3
Soft drab-colored shales	3
	17

Some of these shales contain traces of fossils. These beds are stratagraphically between 300 and 350 feet lower than the fossiliferous exposures on Thunder Hill. A short distance farther down the river I noted the following section of a bank, in descending order:—

	FEET.
Concealed by a land-slide	40
Laminated shales (drab)	5
Concealed by clay which contains slabs of fossiliferous limestones.	15
Laminated drab shales	5
Fossiliferous limestone forming the base, of which are exposed....	4
	69

Near this section are springs depositing yellow ochre. A little further down I observed other springs at which the process of petrifying wood, moss and leaves was going on. Here there were also blocks of calcareous tufa, sometimes measuring several cubic yards, which had been formed at the place where they are found. Numerous large pieces of calcified wood are enclosed in them.

Tufa.

Limestones and shales.

The thickest vertical section of limestone beds which I observed on the river amounted to about fifteen feet. The river, often for long distances, has washed away the shales underlying the limestones, thus causing the overlying beds to sink irregularly. The exposures in this vicinity are found in places extending for about twelve miles along the river. Several miles farther down, or when still about thirty miles from Swan Lake, I found some thin beds of soft micaceous sandstones in thin flags. The whole section between the summit of Thunder Hill and these sandstones (which are the lowest Cretaceous beds exposed) is from 550 to 650 feet thick. Between these last rocks and the underlying Devonian limestones, which are exposed on the islands of Swan Lake, there would be a space of 100 to 150 feet, of which no section was observed along Swan River. Probably some of these concealed measures are a continuation downwards of the Cretaceous formation, while the Devonian may perhaps be continued upwards to meet them.

Fossils.

Almost all the Cretaceous limestones are fossiliferous, as well as some of the shales. The most common fossils are one or two species of *Inoceramus*, and numerous small shells, which, according to Mr. Whiteaves, belong to a species of *Ostrea*. In the lower beds I found the remains of a Cestraciont Selachian, which, from the form of the teeth, Mr. Whiteaves considers to belong to the genus *Ptychodus*, or one allied to it. He also recognizes fragments of scales of other fishes in the same rocks. Some remains of plants were also found.

Shale.

Along Bell River, in the Porcupine Mountains, there are large exposures of Cretaceous shale; but the clayey matter predominating so largely, landslides are frequent, and cover with clay many beds, which, if exposed, might be of great interest. At one of these exposures of shale, which is now weathering into clay, an immense slide has occured. The shales here contain much iron pyrites, and on weathering, a whole section will become blackened by the formation of ferrous sulphide, whilst the remainder of the sulphur is partly deposited in the crevices, where it is sometimes found in considerable quantities. Much heat is at the same time evolved, and there is a strong sulphurous smell while the process is going on. The Indians know this place by the name of

Burning Mountain.

Burning Mountain; and my guide informed me that for several winters it had smoked, but not in summer. This was probably the vapor generated by the heat of decomposition condensing in the cold atmosphere of the winter, but which became invisible at the summer temperature.

Sections of the limestones of Swan River, and of the marls of Thunder Hill, having been prepared for microscopic examination, they were handed to Mr. George M. Dawson, who reports as follows:—

Mr. G. M. Dawson's notes.

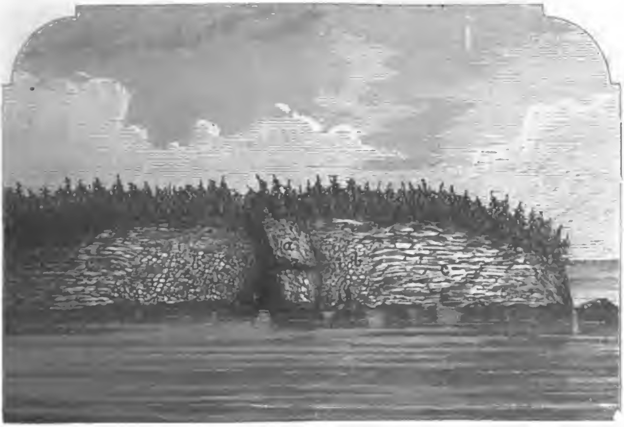
"The specimens from Swan River and Thunder Hill are essentially similar, and are almost entirely composed of separated prisms of shells of *Inoceramus*, with *Foraminifera*, and some scattered fragments of fish bones and scales, the latter being conspicious from their bright brown color. The limestone, in microscopic character, much resembles that from Boyne River, Pembina Mountain, but is somewhat harder. Specimens of the latter were transmitted to me by Mr. A. L. Russel, and have been referred to the Niobrara division, or, Cretaceous No. 3, of Meek and Hayden. The *Foraminifera* appear to agree very closely with those of the Boyne River beds, and of the limestone of the Eau Qui Court, Nebraska; the genera *Globigerina*, *Textularia* and *Discorbina*, being represented in all three localities. All the forms represented by the specimens from Swan River and Thunder Hill bear a close resemblance to those of the more southern localities, and the *Textularia* is referable to *T. pygmæa*, one of the two species represented there. The prisms of *Inoceramus* are more abundant in proportion to the *Foraminifera*, than at Eau Qui Court, or at Boyne River, and in the relative abundance of *Globigerinæ* to other forms the specimens more nearly resemble those of the Nebraska deposit; such differences might, however, obtain between two contiguous beds. Small fragments of fish remains are common to the three localities. As most of the *Foraminifera* found in these deposits are still represented in the Atlantic, they do not form, in themselves, a very definite criterion of the age of the beds containing them. Their occurrence in such quantity, however, at least implies similarity of conditions in the different localities, and as the Niobrara period is the only one in which calcareous deposits of this kind are known to have been formed in the eastern region of the Cretaceous, a strong probability is established that the rocks represent that division. The specimens from Boyne River showed also, in some places, numerous valves of *Ostrea congesta*, a characteristic form of the Niobrara group. *Coccolites* are not evident in the Swan River and Thunder Hill specimens, while they occur in other localities, but are, perhaps, only masked by the superior induration of the rock, a careful examination of some of the soft parts of which might lead to their discovery."

Deposits of Devonian Age.

Devonian limestones.

The rocks of this age which came under my notice consist entirely of limestones. The highest beds exposed, such as those on Warren Island and Point Wilkins, are made up of apparently concretionary nodules. These beds, on disintegrating under the action of the waves, leave at their base hard clean gravel, or nodules of limestone. Almost all the rocks on the western side of Lake Winnipegosis are of light yellowish colors, while those observed on the eastern and southern sides are greyish. At Point Wilkins, on Dawson Bay, a cliff rises to the height of sixty feet. The upper beds consist of the concretionary limestone just noticed, and the lowest are red indurated marls, while between them are forty feet of evenly-bedded whitish limestone. In many places on Swan Lake and Lake Winnipegosis, the exposed rocks appear to have been washed away along the water-level, leaving caverns of considerable size, or else the superincumbent beds have fallen down, owing to the sinking or dissolving away of the underlying strata, thus forming a broken and confused mass. This structure is particularly noticeable at Point Wilkins, where the red marls at the base of the cliff have, apparently, been washed away for a considerable distance, leaving a long low cavern,

Confused portions.



POINT WILKINS, DAWSON BAY.

the roof of which has fallen in, and the superincumbent beds, afterwards sinking, have compressed the whole into a mass resembling a piece of rubble-work, as shewn at *b b* in the above sketch. The cliff may have once extended further into the lake, and its present appearance has probably resulted from the falling down and removal of the rock since the filling up of the supposed prëexisting cavern. Towards the limits of the confused portion, the beds gradually become distinct and assume the horizontal attitude represented at *c c*. In the sketch, *a* represents what appears to have been formerly a projecting portion of the upper bed, now fallen to a perpendicular position.

Distribution of Devonian rocks.

The Devonian limestones appear to occupy the whole of the flat country between the foot of the Duck and Porcupine Mountains and Lakes Winnipegosis and Manitoba, and also the eastern shores of both these lakes. The best localities for fossils, so far as my observation extended, are Warren Island in Swan Lake, and Points Wilkins and Carrolida on Dawson Bay. The palæozoic fossils, which I collected, have been determined by Mr. Billings, who pronounces them all to be of Devonian age. The following were collected from rocks *in situ* at the above localities: *Athyris, Cyrtina, Atrypa aspera, A reticularis* (Devonian type), *Spirifera* and *Orthis.* The following were obtained on the western shore of Dawson Bay, from slabs apparently derived from the neighboring cliffs: *Receptaculites* (?), *Favosites* (2 species), *Syringopora Acervularia profunda* (this occurs in the Hamilton group in Iowa) *Heliophyllum* (like *H. Halli*), *Diphyphyllum, Stromatopora,* crinoidal columns, *Gypidula, Rhynchonella, Atrypa reticularis, Athyris, Strophomena,* a brachiopod resembling *Stringocephalus, Euomphalus, Pleurotomaria, Loxonema, Bellerophon* and *Phillipsia.* Among other specimens, which had evidently been transported from a greater or less distance, there were *Pentamerus, Atrypa reticularis, A. aspera, Strophomena, Chonetes, Euomphalus,* &c

Fossils.

ECONOMIC MINERALS.

Economic minerals.

The minerals of economic value which came under my notice consist of clay iron-stone, lignite, peat and salt. In many places along Swan River, and in the Porcupine Mountains, clay iron-stones are abundant. They are of a concretionary character, contain a considerable quantity of calcareous matter, and belong to the limonite group of iron-stones. In two specimens which I analysed the proportion of iron is low, one of them yielding only 12·90 and the other 16·70 per cent. In the lignite, which I collected on Sander's River, already referred to, the woody structure is

Iron-stone.

Lignite.

apparent; the color is nearly black, with very dark streak: lustre sub-resinous on transverse sections, but dull when the mineral is broken longitudinally; fracture sub-conchoidal; tough. It does not disintegrate very readily. An assay gave the following results:—

	Slow coking.	Rapid coking.
Fixed carbon	50.700	49.000
Volatile matter	26.325	28.025
Ash	4.150	4.150
Hygroscopic water	18.825	18.825
	100.000	100.000
Ratio of volatile to combustible matter	1 : 1.93	1 : 1.81

The coke was pulverulent, and the ash light buff-colored.

Peat.

A few miles below The Crossing on Swan River, two beds of peat are exposed in the bank, the thickest of which measures eighteen inches. Above it is a foot of clay, and then nine inches more of peat, the latter being buried by a few feet of surface soil.

Salt.

Salt was formerly made from the brine springs near the mouth of Bell River. The salt springs at the south end of Lake Winnipegosis have been worked for a long time. At these springs the saline waters percolate through the drift, which in this region covers but thinly the Devonian limestones, and destroys vegetation for some distance around. The manufacture of the salt is conducted in a rude manner. Pits are dug four or five feet deep, and into them the waters infiltrate. Beside these temporary furnaces are erected, on which are placed evaporating pans made of iron plate one-eighth of an inch thick and five or six feet long, by about three feet wide and eight or ten inches deep. Beside the pans, are trays on to which the salt is raked. No pumps are used, the water being lifted into the pans directly from the pits by means of pails. The operation is conducted entirely in the open air. The manufactured salt is put into birch-bark boxes, or "mococks," holding about 100 pounds each, and is then ready for market. During the season Mr. McKay, the only person engaged in the business, made about 500 bushels, or less than half the quantity which had been manufactured in some previous years.

The following is an analysis, by myself, of a sample of the salt which I brought from the works:—

Sodium chloride	95.123
Magnesium chloride	0.600
Calcium sulphate	3.400
Sodium sulphate	0.394
Moisture	0.044
Residue	0.439
	100.000

The residue consists of silica, alumina, iron and lime. The salt has a light brown tint, and is very coarse-grained, owing to the manufacturer allowing the crystallization to go too far undisturbed.

JOSEPH WILLIAM SPENCER.

REPORT

OF

MR. JAMES RICHARDSON

ON EXPLORATIONS IN

BRITISH COLUMBIA,

ADDRESSED TO

ALFRED R. C. SELWYN, F.R.S., F.G.S.,

DIRECTOR OF THE GEOLOGICAL SURVEY OF CANADA.

1874–75.

Sir,—Early in April last, I received your instructions to proceed again to British Columbia, for the purpose of continuing and extending the geological explorations which were made there during the three previous years.

Instructions.

With this object in view, I left Montreal on the 4th of April, and on the 21st reached San Francisco. The direct mail steamer for Victoria having sailed the day before, I proceeded by steamer, via Portland in Oregon, reaching Victoria on the 30th of April.

Arrival at Victoria.

In my instructions I was informed that Mr. Charles Horetzky had been directed to examine, for railroad purposes, various inlets and channels on the west coast of the mainland to the north of Vancouver Island, and that he would accompany me, and the same means of transport be thus made available for both the railroad and the geological explorations. Early in May Mr. Marcus Smith, Chief Engineer of the Canada Pacific Railroad surveys in British Columbia, reached Victoria, and as I then received definite instructions from him, I lost no time in hiring a sloop of about 15 tons burthen, with Abel Douglas as Captain, and a crew of three men. Having placed my field equipment on board, and also the provisions required for my own and for Mr. Horetzky's party, the sloop left Victoria on the 15th of May, and on the 19th I followed by steamer,

Arrival of Mr. Marcus Smith.

Sloop hired.

Departure from Victoria.

with Mr. Horetzky's two assistants, and joined the sloop next day at Nanaimo.

Nanaimo to Gardner Channel.

Having procured a few additional articles which were required, we left Nanaimo on the 21st of May, and arrived at the entrance to Gardner Channel on the 1st of June. Here on account of calms and adverse currents we made very little progress for several days. On the 7th, however, the Hudson Bay Company's steamer "Otter" arrived with Mr. Marcus Smith and Mr. Horetzky on board, and taking the sloop in tow brought us in a few hours to Kamino Bay, about fourteen miles from the head of Gardner Channel. Mr. Horetzky's explorations inland, here, and at the Kitimat, and my own around Gardner and Pender Channels and Kitimat Inlet were completed by the 1st of August, and we then returned to Bella Bella or McLaughlin Bay, on Campbell Island.

Kamino Bay.

Return to McLaughlin Bay.

Mr. Horetzky now wished to proceed up Dean Channel, to make further inland explorations there. But from the great uniformity in the character of the rocks throughout the region already examined, it was evident that his explorations would require much more time than mine were likely to, and therefore, to avoid delay, I thought it best to separate from him here. I accordingly transferred the sloop to his charge, and directed one of the men who accompanied her to take every opportunity of collecting specimens of the rocks met with, and at the same time to carefully note and record their attitude and characters in such a manner as to enable me to form an opinion of the geological structure at the localities visited.

Leave Mr. Horetzky.

On the 11th the "Otter" arrived at Bella Bella, on her way to Wrangel, on the Stickeen River, and I availed myself of this opportunity to visit the various places at which she touched, and to return with her to Victoria. In this way I procured specimens of the rocks, and much valuable information relating to the general geological features of the coast at a number of points not previously examined between Victoria and the mouth of the Stickeen River in Alaska. And I wish here to express the obligations I am under to Captain Lewes for his uniform kindness and courtesy, and for the trouble he took in landing and embarking me for the purpose of making observations at every point at which the steamer called.

Wrangel on the Stickeen River.

Acknowledgment of assistance.

On my return to Victoria, on the 20th of August, I discharged my two men, and during the remainder of the season, which was occupied in the Nanaimo coal-field, I relied on the assistance I could get from Indians or others, as occasion required. Early in November wet and stormy weather set in, and on the 5th I returned to Victoria. While there, preparing for

Nanaimo coal-field.

my departure for Montreal, I received instructions from you by telegraph to make a collection of specimens of the principal rocks met with in the Canons of the lower Fraser River, between Yale and Lytton, and on the Thompson, as far as Spencer Bridge. I therefore left by the first steamer for the mainland, on the 10th, and having carried out these instructions reached Victoria again on the 26th of November.

Collection of rocks on the Fraser and Thompson.

The specimens collected during the season were then re-packed, filling seven boxes, which were forwarded to Montreal. The field equipment was properly cleaned and stored at the offices of the Canada Pacific Railway, and the boat which I had left with Mr. Horetzky was placed by him, on his return to Victoria, in the Hudson Bay Company's warehouse.

On the 11th of December, I finally left Victoria, and reached Montreal on the 23rd.

Return to Montreal.

GEOLOGICAL FEATURES.

From the foregoing summary, it will be seen that the season's operations extended over two geologically and geographically distinct areas. The first embraces the shores of a number of channels, inlets and islands, lying between 51° 25′ and 56° 5′ of north latitude, the whole of which, with one exception, are, so far as observed, occupied by more or less crystalline rocks, the precise age of which can not at present be determined. The second embraces the south-eastern portion of the main Nanaimo coal basin, and several detached portions of it on Vancouver Island, as well as others on various islands in the Strait of Georgia, and on the mainland at Burrard Inlet, and at the mouth of the Fraser River, all of which, though separated by water, are probably not geologically detached, but form part of the same basin.

Two distinct areas examined.

In the area to which my attention was first directed, the general sameness of the geological features renders any detailed or elaborate description unnecessary, and the various localities examined will, therefore, be mentioned as briefly as possible.

Sameness of geological features in first area.

In your preliminary report on the geological exploration of British Columbia, Report of Progress 1871-72, page 54, you have grouped the rock formations under the following divisions—reversing the order of their deposition—which subsequent explorations have afforded me no grounds for deviating from:—

Grouping of rock formations

I. Superficial deposits.

II. Volcanic series and coal and lignite group of the mainland, and the coal-rocks of Vancouver Island.

III. Jackass Mountain group.

IV. Upper Cache Creek group (Marble Canon limestones.)
V. Lower Cache Creek group.
VI. Anderson River and Boston Bar group, and upper rocks of Leather Pass and Moose Lake.
VII. Cascade Mountains and Vancouver Island crystalline series.
VIII. Granite, gneiss, and mica schist series of the North Thompson, Albreda Lake, and Tête Jaune Cache, including the micaceous schists of the Cariboo district.

Only two, or perhaps three, of the above divisions, namely, I., VII. and VIII., appear to be represented in the area under consideration.

I.—*Superficial Deposits.*

In describing these the character of the vegetation and other surface features will also be briefly noticed.

Clay, sand, and gravel.

Black vegetable soil.

Deposits of stratified clay, sand, and gravel are of rare occurrence; but around the shores and on the lower parts of the mountains, the rocks are for the most part directly overlaid by a thin layer of black vegetable soil, which supports a tolerably thick forest, consisting of white spruce, white pine, and cedar, many of the trees measuring from two to three feet at the base, and running up from forty to sixty feet without a branch. The great extent of these forests, and their proximity to navigable waters, are elements which at no distant date will probably make them of very considerable value and importance.

Valuable forests.

Ice and snow on the mountains.

At elevations of from 1,500 to 2,500 feet, the trees are stunted, and bare rocky surfaces prevail and extend upwards to where, unless too precipitous, they become covered by extensive fields of ice and snow at from 3,000 to nearly 7,000 feet above the water. In many places snow and ice slides or torrents of water have swept down the sides of the mountain, carrying everything before them into the sea below, their course being marked by long lanes of bare smooth rock from a few feet to as much as a hundred yards in width.

Shores exhibiting features similar to the above.

Similar features are characteristic of the shores of all the undermentioned channels, sounds and passages:—

Fitzhugh Sound, Fisher Channel, Dean Channel, Gunboat and Lama Passages, Seaforth Channel westward to Milbank Sound, Matheson Channel, Oscar Passage, Finlayson Channel, Tolmie Channel, Graham Reach, Fraser Reach, Ursula Channel, McKay Reach, Wright Sound, Douglas Channel, Verney Passage, Pender Channel, Gardner Channel, and Kitimat Inlet.

Around Kitimat Inlet there are a few places where the land is comparatively level, and a belt of level land extends along the Kitimat River, which falls into the head of the inlet. This belt is from four to seven miles wide from east to west, and not less than thirty miles in length from north to south. In one place where a slide has occurred on the bank of the river, the deposits of brown sand, with some clay, which form this level tract are seen to be about 200 feet thick. The whole of it is covered by a thick growth of white spruce (*Abies alba*) and some hemlock, from one to two feet in diameter at the base. A small species of birch is also occasionally met with. Another locality where similar deposits were observed is at the Kitimat Indian Summer Village, about three miles south from the head of the inlet on the east side. Here a terrace of brown sand rises behind the village to a height of from 100 to 150 feet, and occupies an area of about 20 or 25 acres. On the west side of the inlet a few miles further south, at the mouths of two un-named streams, there are from thirty to forty acres of flat land. At the mouths of these streams, as well as at the mouth of the Kitimat River, there is a belt of land, covered with strong coarse grass, which is flooded by the tide at high water. At the mouth of the Kitimat River the area of it can not be much short of 200 acres. The grass would, if properly dried, make good hay.

Level land on Kitimat Inlet and River.

Thick deposits of sand and clay.

Spruce, hemlock, and birch.

Kitimat Indian Summer Village.

Grass.

At Bella Bella, on Campbell Island, there are a few acres under cultivation. At Metlah Catlah and Fort Simpson, in Chatham Channel, likewise a few acres are cultivated—at the former place by Mr. Duncan, and at the latter by the Hudson Bay Company. At both places, but especially at Metlah Catlah, the Indians have small gardens, and grow cabbages, onions, carrots and potatoes with considerable success. It is said that on account of the want of sufficient sunshine and the excess of rain, grain will not ripen in this region.

Land under cultivation at Bella Bella, Metlah Catlah and Fort Simpson.

VII.—*Cascade Mountains and Vancouver Island Crystalline Series.*

The examination of these crystalline rocks (with which some are perhaps included that belong to group VIII.) was commenced on the south at Cape Calvert, the extreme southern point of Calvert Island, which forms a part of the western shore of Fitzhugh Sound. The Cape rises to a height of about 1,200 feet, and on the same island about twelve miles to the north, Mount Buxton rises to 3,430 feet. On both sides of the Sound the mountains are rarely less than 500 feet in height, while near the entrance to Burke Channel, they rise to as much as 3,380 feet. These conspicuous elevations, like the shores from which they rise, consist almost entirely of a light grey syenite, or syenitic granite, composed of

Cape Calvert.

Mount Buxton.

Grey syenite.

white feldspar, quartz, black hornblende and black mica. Similar rocks extend northward on both sides of Fisher Channel, and are also seen on Denny Islands on the west and as far as Even's Arm on King's Island on the east. At McLaughlin Bay, or Bella Bella, on Campbell Island, there is a considerable extent of fine-grained granite, composed of yellowish-white feldspar, quartz, a little dark-colored hornblende and scales of silvery mica. In Gunboat Passage, the rocks are a finely laminated grey gneiss, containing both hornblende and mica, and dipping south at an angle of 65°. Similar rocks prevail on both sides of Dean Channel to some distance beyond Cascade Inlet, the rocky masses rising on both sides abruptly from the water to heights of from 2,000 to 6,000 feet.

Granite at Bella Bella.

Grey gneiss.

Rocks of Don and other Islands.

Don, Lake, Lady, Mary, and Dowager Islands, which lie to the north-east of Milbank Sound, are all composed of grey granitic rocks, which rise in escarpments from the water's edge to heights varying from 500 to 2,400 feet. In these rocks, black hornblende sometimes predominates, but generally white feldspar, quartz, and black mica are most abundant. In many places they exhibit contorted and twisted lamination, while at others they resemble crystalline intrusive masses in which no trace of laminated structure can be detected. The general strike of the laminated portions is about W. 12° N., and E. 12° S. On Lake Island to the south of Moss Passage, there is a small patch of conglomerate sandstone lying nearly flat on the upturned edges of the gneisses. It resembles some of the conglomerate sandstones of the productive coal measures, or division A., Report of Progress, 1872-'73, page 35; and although no fossils were observed in it, I have no doubt that it belongs to this division of the coal-bearing Cretaceous rocks. Its presence here is of great interest, as an evidence of the former extension of the Cretaceous formations throughout the region, and of the enormous amount of denudation to which they have since been subjected. At Parker Point on Roderick Island, to the north of Milbank Sound, bedded dioritic rocks are well exposed, in thicknesses of from six inches to one foot. Northward from this point and from Jorkins Point opposite, on Swindle Island, both shores of Finlayson Channel, as far as Cone and Jane Islands, consist of similar dioritic strata.

Cretaceous rocks

Dioritic strata.

Sarah Island, the south end of which is about one mile north of Jane Island, is a long narrow Island lying between Finlayson Channel on the east, and Tolmie Channel on the west. From the south end of Sarah Island northward to a small cave on the west side there is no change in the rocks, but on the eastern side of the cave they are associated with pinkish-colored, compact limestone, interstratified

Limestone on Sarah Island.

with greenish-grey beds holding crystals of white calc-spar and small specks of silvery looking iron pyrites. The beds are from half an inch to one foot thick, and dip S. 63° W. < 74°. Proceeding north in Tolmie Channel for about eight miles, dioritic rocks only are seen on both sides, after which, on the west side, they are again associated with limestones. The strike of these beds is N. 11° W. and S. 11° E., but as the dip is either vertical or at high angles in both directions, it is impossible to be certain whether the following section of the beds is in ascending or descending order:—

Section on Tolmie Channel.

	FT.	IN.
Brownish black hornblende and mica schist, finely laminated in thicknesses of one-tenth of an inch to one inch	52	0
Grey, crystalline limestone..............................	4	6
Concealed..	120	0
Bluish-grey limestone, finely laminated..................	24	0
White, coarsely crystalline limestone	2	6
Closer grained yellowish-white limestone, finely laminated..	6	0
Very coarsely crystalline limestone, white, with a bluish tinge	17	6
Limestone, same as last interstratified with brown-weathering calcareous mica schists; silvery white mica abundant...	32	0
Concealed..	6	0
Limestone and schists same as last.......................	18	0
Limestone and schists same as last, with grey dioritic beds..	60	0
Concealed	12	0
Grey siliceous beds, slightly calcareous, weathering to a reddish-brown and finely laminated....................	31	0
Coarse grey limestone, alternating with grey dioritic layers in thicknesses of a quarter of an inch each............	25	0
	410	6

The next five miles northward in Tolmie Channel, to Graham Reach, are occupied by the usual dioritic rocks and gneisses. They are for the most part finely laminated, and strike N. 46° W. and S. 46° E. At the entrance to Graham Channel they are again interstratified with grey crystalline limestones, and were observed for about a mile along the coast or to a little north of Green Inlet, opposite which the beds dip N. 46° W. and S. 46° E. < 12° to 40°. For about 6 miles further along Graham Reach to Swanson Bay the rocks are all gneisses. In Swanson Bay the beds are finely laminated, and consist of greyish black mica schists, alternating with light grey beds, composed of white quartz, feldspar, and silvery mica, with fine specks of black hornblende.

Graham Channel.

Swanson Bay.

From Swanson Bay to Warke Island at the commencement of Fraser Reach, a distance of about fifteen miles, the rocks are less laminated,

Fraser Reach.

Granite.

and more granitoid in character, and from this northwards for a distance of about twelve miles on both sides of Fraser Reach, granite, composed of white feldspar, quartz and fine scales of black mica, is the prevailing rock. Sometimes the mica is very scarce or is replaced by black hornblende. Continuing northward and westward from Fraser Reach, similar rocks are met with at the following places: On both sides of McKay Reach; at Turtle Point on Gill Island; on Promise Island and Hawkesbury Island; on the mainland north-west of Douglas Channel; on the east and west sides of Ursula Channel to Mary's Point, and thence to Point Stainforth at the entrance to Gardner Channel. The extent of this area from south to north is about forty-four miles, or from Fraser Reach to Point Carey, on Hawkesbury Island, and from west to east nineteen miles, or from Douglas Channel to Point Stainforth. How far these rocks extend beyond the area examined can only be determined by future exploration; and even within it it is not impossible that other formations may exist which were not observed. One place may be noted where rocks of a somewhat different character were observed. These occur on the north side of Kit Kia-tah Bay, on the west side of Douglas Channel. They consist of finely laminated beds of blackish hornblende schists interstratified with greenish chloritic and micaceous schists, which are sometimes calcareous. There are also some thin beds of yellowish crystalline limestone with scales of black mica. The hornblende is generally finely disseminated, but where chlorite and mica predominate it shews itself in large scattered crystals, which from their superior hardness appear in relief on the weathered surfaces. These beds are all of them much twisted and disturbed, but their general strike is N. 68° W. and S. 68° E. < 51°. They occupy the north side of the bay above named, and extend to the northward along Douglas Channel for about half a mile, when they are succeeded by granitoid rocks, though their contact with the latter was not seen.

Various localities visited.

Rocks of Kit Kia-tah Bay.

Among the broken up beds on the north side of the bay (Kit Kia-tah) there are numerous pieces of the softer rocks, which have been carved to represent various animals—fishes, birds, and quadrupeds—as well as grotesque human faces. The manner in which these occur mixed with the loose material along the beach would indicate that they are of considerable antiquity. The Indians residing in the neighborhood say they have no knowledge when or by whom these curious relics were fashioned.

Curious carvings.

The rocks remaining to be noticed are in Gardner Channel eastward from Stainforth Point, and in Pender Channel northward from the same point to the head of Kitimat Inlet.

Gardner and Pender Channels.

Mica schist in Crab Bay

On the north side of the entrance to Gardner Channel, in Crab Bay, the rock is a finely laminated mica schist, dipping S. 45° W. < 81°. On Channel Island, as well as on the south shore opposite, are grey and black mica schists, which at the latter point are interstratified with bluish-yellow crystalline limestone, in beds of from two to six inches thick. The greatest thickness wholly of limestone is about twelve feet, while the total thickness of the calcareous group is not less than 100 feet, dipping N. 77° E. < 65°. At about seven miles from Stainforth Point, and thence to and around Triumph Bay, on the south shore, the rocks are often obscurely laminated. They are for the most part composed of white feldspar and quartz, with scales of black mica. The strike where observable is nearly north and south. On the north shore of the Channel, about four miles eastward from Triumph Bay, the dip is S. 67° E. < 21°, while about one mile further east, on the south shore, it is S. 52° W. < 60°, and five miles further, on the north side, S. 57° W. < 64°. The rocks at the three last mentioned localities are grey gneisses, sometimes finely laminated, but often massive and exhibiting no trace of laminated structure.

Crystalline limestone.

Triumph Bay.

Gray gneisses.

Fifty miles eastward from Stainforth Point, or about five miles above the mouth of the Kamino River, was the eastern limit of my exploration in Gardner Channel. The valley of the Kamino River was examined by my assistant, Robert McLaughlin, for a distance estimated by Mr. Horetzky at about twenty-five miles from the sea. Neither in this upper part of the channel, nor in the Kamino valley, was there anything observed in the character and attitude of the rocks different from that which has already been described in its lower portion. Pender Channel stretches northward, as already stated, from Stainforth Point to Hopkins Point on the east, and Carey Point on the west. Having traversed this part of the channel during the night, the rocks were not examined, but it is not probable that they differ much from those which were found on either side, namely, in Gardner Channel, to the south-east, and in Kitimat Inlet, to the north.

Valley of Kamino River.

Pender Channel.

For a distance of about seven miles on the east side of Kitimat Inlet, or from Hopkins Point to Kildala Arm, the rocks are grey granitoid and hornblendic gneisses, imperfectly laminated. Near the arm, however, the lamination is well defined, and at its southern entrance, at the base of an almost perpendicular cliff of about 1,500 feet, the rocks are mica schist, interstratified with beds of dark-grey diorite, and dip N. 60° E. < 43°—56°. At the entrance to the arm on the north, similar beds were observed dipping N. 58° E < 73°. From here to Eliot Point, and Every

Hopkins Point to Kildala Arm.

Clio Bay.

Point, respectively south and north of Clio Bay, and around Clio Bay, as well as at Turnour Island, the rocks are either granite, diorite, or mica schist. Generally the gneissoid structure is obscure, but sometimes well marked. On both sides of the inlet, from Every and Chitterbuck Points, northward to its head, similar rocks prevail, excepting at about one mile to the north of the Kitimat Indian Summer Village, where a mountain, named "Photograph Mountain" by Mr. Horetzky, rises to a height of 1,500 feet, and extends to the inside harbour, a distance of nearly three miles. The rock composing it is a massive grey granite, shewing no trace of lamination, and consisting of a very uniform aggregate of greyish-white quartz and feldspar, black hornblende and scales of mica.

Photograph Mountain.

Specimens collected by Mr. McLaughlin.

Specimens of the rocks collected by my assistant, Robert McLaughlin, on two excursions which he made inland from the head of the inlet with Mr. Horetzky, one of about 50 miles east, and the other 30 miles north, shew them to be throughout either granitoid gneisses, diorites, or mica schists.

The Coast from Douglas Channel to Wrangel in Alaska.

As already stated, a trip was made along this portion of the coast in the H. B. Co's. steamer "Otter," but as a landing was made at only four points, no detailed description can be given of the rocks generally, except at the localities alluded to. As observed, however, from the steamer in passing along the shores, they present throughout, or at least after passing the first 50 miles up Grenville Channel, very marked differences—physically rather than mineralogically—from those which were observed further south, from Douglas Channel to Milbank Sound; and a corresponding difference is likewise observed in the physical outlines of the country, which is far less precipitous, and generally less elevated and mountainous.

Gibson Island.

From the point above named to Gibson Island, at the head of Grenville Channel, the rocks on both sides are distinctly stratified, and similar distinctly bedded rocks were noticed on the islands, and on the mainland for eighteen miles further north, to a place known as Woodcock Landing in North Skeena Passage. At Woodcock Landing the rocks are of a dark blue color, almost black, fine-grained, generally more or less calcareous, and show numerous small brilliant specks or grains of a mica-like mineral. The beds are from two to ten inches thick, and dip N. 24° E. < 25°—40°. Similar rocks occupy the east sides of Chatham Sound, for fourteen miles further north to Metlah Catlah Bay,

Rocks at Woodcock Landing.

Chatham Sound.

Rocks at Fort Simpson.

where they dip S. 24° E. $<$ 18°—30°. At Fort Simpson the bedded character of the rocks is still very marked. Those observed, and of which specimens were collected, are brilliant mica schists, garnetiferous gneisses, and highly hornblendic crystalline white limestones. The dip here is N. 52° E. $<$ 24°—38°.

Fort Wrangel.

At Fort Wrangel, about 150 miles north-west from Fort Simpson, there are dark blue, or grey, soft, finely-cleaved clay-slates, in which numerous brilliant micaceous looking spots or scales have been developed. They are more or less oblong and seldom exceed a quarter of an inch in their greatest length. The faces of these spots are always more or less transverse to the cleavage planes, which correspond with those of bedding and give a porphyritic aspect to the slate. The nature of the mineral forming these scales has not yet been determined. Interstratified with the slates, in beds of from two inches to eight inches in thickness, is a dark blue, finely-granular, or micro-crystalline rock, which is slightly calcareous, and has minute particles of apparently the same micaceous looking mineral thickly disseminated through it. The dip of these slaty beds is N. 25° E. $<$ 36°—45°.

Age of crystalline rocks.

Though, as already stated, we are not yet in a position to speak authoritatively on the question of the age of this great series of crystalline rocks, or to say whether eventually different portions of them will be proved to belong to distinct epochs, yet it may be remarked that generally they present such a wonderful uniformity in character, wherever they have been examined through seven degrees of latitude, from New Westminster on the Fraser River to Wrangel on the Stickeen River, and through six degrees of longitude, from Vancouver to Cariboo and Tête Jaune Cache, as to favor the idea that they constitute one great and wide spread series, and that such differences as have been observed are due rather to the degree of metamorphism to which they have locally been subjected than to any wide difference in their geological age. They are doubtless the gold-bearing rocks of British Columbia, and will probably, when more closely examined, be found to contain other valuable minerals. During the past season, however, with the exception of traces of galena and of copper pyrites, east of the inner Kitimat harbour, no ores of economic value were observed.

Metamorphism.

Ice Grooves.

Channels cut by ice.

Throughout the whole of the inlet and channels which were examined, wherever the surface of the rock is exposed, the ice-grooving and scratching is very conspicuous, from mere scratches to channels often several feet in width, and from a few inches to as much as two and three feet deep.

Often they can be distinctly seen with the naked eye, from the surface of the water to upwards of 3,000 feet above it on the sides of the mountains. They run in more or less parallel lines, and are not always horizontal, but deviate slightly up or down. Sometimes the rocky surface resembles that of a field covered with narrow ridges. Where two vallies meet, the upward deviation is always well marked on the side of the smaller valley. A good example of this occurs at the junction of the Kamino Valley with that of Gardner Channel, where on the west side the hard gneissose rocks are scooped out in wide deep grooves, occasionally undercut on the upper side, and rising from the level of the water at angles of from eight to fifteen degrees.

Direction of grooves.

It would be useless to enter into any great detail as to the direction of the grooves. Generally, it conforms with that of the vallies, and the movement of the ice has been from north, north-west, north-east and east to the opposite point, modified by the sinuosities of the vallies through which it passed.

THE NANAIMO COAL BASIN.

Some further progress was made towards the close of the season in working out the details of the structure of the south-eastern portion of the Nanaimo coal basin, the complicated nature of which was alluded to in my last report—Report of Progress, 1873-74, pp. 96-97. As it is not yet completed, the result of the work will be deferred for a future report, and I shall now simply mention the localities which were visited and examined, and those from which fossils were collected.

Work not completed.

Localities visited.

On Vancouver Island, these were Cowitchen Harbour, Maple Bay, Osborn Bay, and Horse-shoe Bay; also two small detached areas or outliers, the one at Sooke, and the other further to the west, both of them in the Strait of Juan de Fuca. In the Strait of Georgia, and in Haro Strait, the islands where observations were made, are part of Admiralty or Salt-Spring Island, also Sydney, Stuart, Waldron, and Sucia Islands. The two last named are now in United States territory, but are geologically connected with the Nanaimo coal basin. The rocks of Sucia Islands, and of another small island of the same group, belong to the Productive Coal measures, or Division A.—Report of Progress, 1872-73, page 35. From these about 400 specimens of well preserved fossils were collected, and have been placed in the hands of Mr. J. F. Whiteaves for examination

Fossils.

and description. On the mainland, observations were made at Burrard Inlet and on the lower part of the Fraser River.

Coal or lignite.

Coal or lignite in small quantities was observed at the following places:—

1. On an island of the Sucia group, in lumps of from two to ten inches in length and thickness. A good clean coal.
2. On the beach at the entrance to Sooke Harbour in similar lumps.
3. On a small stream about seven miles west of Sooke, in a seam of about a quarter of an inch thick.
4. At English Bay outside the narrows at the entrance to Burrard Inlet; lignite in lumps two or three inches thick, and two to fifteen inches long.

During the season a collection of botanical specimens was made. It has since been examined by George Barnston, Esq., of Montreal, who has kindly named the plants; a catalogue of which will shortly be published in the "Canadian Naturalist."

I have the honor to be,
Sir,
Your obedient Servant,
JAMES RICHARDSON.

GEOLOGICAL SURVEY OFFICE,
MONTREAL, *March*, 1875.

SUMMARY REPORT

OF

GEOLOGICAL OBSERVATIONS IN NEW BRUNSWICK.

BY

PROFESSOR L. W. BAILEY AND G. F. MATTHEW, ESQ.,

ADDRESSED TO

ALFRED R. C. SELWYN, ESQ., F.R.S., F.G.S.,

DIRECTOR OF THE GEOLOGICAL SURVEY OF CANADA.

SIR,—In accordance with instructions, we beg to submit the following summary Report on the geological observations made by us, with the assistance of Mr. R. W. Ells, in the Province of New Brunswick, during the past summer.

Map of Queen's and Sunbury Counties.

Having, in the previous season, been engaged in the preparation of a geological map of Queen's and Sunbury counties, our attention was, by your direction, first given to obtaining the data necessary for the completion of the same, and more particularly to the determination of the age and relations of the several belts of argillite rocks, which, in the county first mentioned, extend along the southern border of the coal-field. We have now to state, as the result of these examinations, that of the two groups into which, in a previous report (Report of Progress, 1870-71, pp. 191-200) these argillites have been divided, viz., "the pale argillite series," and "the dark argillite series," no doubt is now entertained by us that the former, as before conjectured, is of Devonian age, being the equivalent, though with somewhat different lithological characters, of the rocks of that age, which, in the county of St. John, have been described under the name of the Cordaite shales. There can also be no doubt that these pale argillites are more recent than the dark argillites against which they rest; but although some facts bearing upon the age of the latter have been obtained, they are not as yet of a character suffici-

Age of the "pale argillite series."

ently satisfactory to enable us to regard their position as definitely determined.

In connection with the above work in Queen's and Sunbury counties, a measured section was made, with a view to obtain a more accurate idea of the thickness and relations of the several formations traversed. The line chosen for this purpose was one extending from Caton's Island, in King's county, near Oak Point, on the long reach of the St. John River, to the border of the coal-field in Clone's Settlement, Queen's county; this appearing to be especially favourable, as intersecting all the formations nearly at right angles, and as presenting fewer difficulties of measurement than would occur elsewhere. This section, submitted herewith, shows all the exposures crossed upon, or immediately adjacent to, the line of traverse, together with the dip of the stratified rocks, and is drawn on a scale of six inches to one mile, horizontal and vertical.

Section.

After making the above examinations in Queen's county, our attention was next directed to the county of Charlotte, where, in part, the same groups of rocks are met with, and where it was hoped that facts might be obtained which would determine the questions left unsettled in the first named county. As bearing upon these questions, it seemed desirable, in the first place, to ascertain if possible the age and limits of the groups of rocks described in the Report of 1870-71 as the "Mascarene" and "Kingston" series, to the latter of which a portion of the argillite series of Queen's county bore a marked resemblance, while there was some reason to believe that the former, associated with these same Kingston rocks in Charlotte county, was of Upper Silurian age, like a portion of the sediments which in Queen's county lie between the argillites and the granite hills. A careful examination was accordingly made of both these groups. No facts tending to fix the age of either were obtained within the limits of the Province, but in extending our observations on the Mascarene series into the adjacent State of Maine, we were fortunate in obtaining information confirming our previous surmises, and definitely fixing the horizon of this group as that of the Upper Silurian formation. The details of these observations, and some remarks on the relations between the different members of the Upper Silurian formation, are given below.

Charlotte County

Age of the Mascarene and Kingston series.

In connection with the study of the different groups of rocks above alluded to, the limits of these, as well in Charlotte as in Queen's and Sunbury counties, were for the most part accurately determined, and have been laid down upon geological maps, which have been duly submitted. As, however, a degree of uncertainty still exists as to the age of a portion

Publication of maps deferred.

of these groups, it has been thought best to defer the publication of the maps and sections, until further examinations shall have been made.

Magnetite of Deer Island.

The only useful mineral, in addition to those already enumerated in previous reports, observed by us in the counties examined, is magnetic iron ore, occurring at what is known as Lord's Cove, on the southern side of Deer Island, in Charlotte county. It is found in veins from two to three feet in thickness, intersecting rocks (slates and imperfect gneisses) of the Kingston (Huronian) series, and is of good quality; but its position on a narrow promontory, and mostly below tide-level, is such as to detract materially from its value.

In addition to the observations on the older groups of rocks, considerable attention was paid to the surface geology of the districts examined; the results of which, together with observations previously made at other points, will form the subject of a future Report.

MASCARENE SERIES.—(Upper Silurian.)

In our Report on the southern counties of New Brunswick, published in the Report of Progress, 1870-71, there was described, on pages 144 to 148, a very peculiar group of rocks, spread over a considerable area in the south-west part of Charlotte county, whose age could not be determined for want of fossils sufficiently characteristic, and which was temporarily designated the "Mascarene series." Lithologically, the lower part of the group resembles the Upper Silurian and Devonian strata seen along the shores of the Bay of Fundy; but the upper part, composed chiefly of diorites, felsites and red slates, could be paralleled only by crystalline and slaty rocks, of the Coldbrook (Huronian) group of St. John county, &c.

The Mascarene series.

As explained above, a portion of the last season's work was given to a re-examination of the area where these Mascarene rocks occur, with the view of ascertaining the bearing on their age of the observations made on the Upper Silurian area at Oak Bay, in the previous season, and of both on the Upper Silurian and argillite rocks of Queen's county.

Character of Division 5.

The best section of the Mascarene strata, viz., that at the Mascarene shore, shows a total thickness of about two thousand feet, the upper three hundred of which consist of dark red felsites or orthophyres, weathering brick-red, (or becoming salmon-colored where the surface is bleached by peat), very fine-grained, homogeneous, full of joints and seams, but compact and hard enough to form conspicuous hills all round Passamaquoddy

Bay. This group, (Division 5)* was traced north-westward into the rough hills back of Bocabec River, where it loses its red color, becomes reduced in thickness, and finally merges into strata resembling those of the upper group of the Upper Silurian series at Oak Bay. These beds contain a *Chonetes* resembling *C. Nova-Scotica*, but in the Passamaquoddy felsites, of Division 5, no fossils have been detected.

Division 4. The underlying group (Division 4) is, at the Mascarene shore, 300 feet thick, and composed almost entirely of argillites of a bright red or green color. In the northern and western parts of Passamaquoddy Bay, however, diorites and fine-grained, dark colored traps are the chief constituents. In the northern part, these, especially the argillites, lose their bright tints and assume a dark purplish hue. In the south-west part of the same bay, the argillites of this group are of a bright red color, and both here and on the eastern side they contain numerous shells of the genera *Modiolopsis*, *Lingula* and *Loxonema*,—genera which are not considered as trustworthy in fixing with precision the age of the beds in which they occur. The group (Division 4) appears to be confined in New Brunswick to the vicinity of Passamaquoddy Bay, as we have not found it in masses worthy of being recognized as a separate group of beds, either to the south-east of that sheet of water, or at any considerable distance north-west of it.

Division 3. The sandstones of Division 3 are about 400 feet thick in Passamaquoddy Bay, and are more widely distributed than the last group. They are met with at many points along the shore of the bay, and at some places contain great numbers of the shells named above. On being traced up the St. Croix River and Chamcook Valley, they were found to change in color to a dark purplish shade, and to be in part made up of very fine-grained rocks. They assume here the color and appearance of the Upper Silurian sandstones on Oak Bay. From Eastport, Maine, near which, at Kendall's Head, the group forms a conspicuous cliff facing Passamaquoddy Bay, it was followed westward to the town of Pembroke, Me., and there found to form the upper part of the section of slates and sandstones which yielded the Upper Silurian fossils described in Prof. C. H. Hitchcock's Report on the Geology of Maine. No exposures of the rocks of the group have been seen between Passamaquoddy Bay and Deadman's Harbor, eight miles east of the bay; but at the latter place there are hard sandstones of this group, of grey and purplish tints. They have a few thin layers of red and green slate and occasional thin beds of fine conglomerate, the pebbles of which are chiefly derived from the Huronian protogine, felsite and schist near by. With these fragments are a few pieces of black flinty slate. The sandstones of Division 3 extend for some distance in the direction of Beaver Harbor.

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* For the subdivisions of the Mascerene series, see Report of Progress for 1870-71 p. 145.

Division 2.

In the underlying group, Division 2, there is, at the Mascarene shore, a thickness of 600 feet of beds, but they do not, like the sandstones described above, come to the surface at other points around Passamaquoddy Bay. About three miles from the latter, however, at the head of the second Chamcook Lake, a set of very fine petrosiliceous rocks, which are almost black, but have a perceptible purplish tinge, appears in connection with the fine splintery purple sandstones of Division 3. The Mascarene rocks of Division 2 are also well represented at Wright's Head, in Beaver Harbor, nine miles east of the Passamaquoddy area. Here the strata are more earthy than the corresponding beds at the Mascarene shore, and the more fissile layers contain remains of plants. These are of several genera, and among them are a narrow *Cordaites*, a large *Cyclopteris*, probably a *Sphenopteris*, and a carpolite, and striate and punctate stems of ferns. The occurrence of more imperfect remains of plants in this group is referred to in a description of the section at the Mascarene shore in a former report.

Division 1.

There remains to be described Division 1, which is about 400 feet thick on the Mascarene shore, but which does not come to the surface in any other part of Passamaquoddy Bay. Outside of this Bay, however, at Back Bay of La Tete Harbor, and at Frye's Island, there are slaty beds, with oceanic species of Upper Silurian fossils, and in the opposite direction, at Oak Bay, the lowest group of Silurian deposits is in like manner slaty.

Comparison between Mascarene deposits and Upper Silurian of Charlotte Co.

In comparing the Mascarene deposits with the Upper Silurian beds north of the crystalline belt, in Charlotte county, their place, as near as can be ascertained is this,—beginning with the lowest:—

UPPER SILURIAN.		MASCARENE.
Grey clay slates............	Division	1. Grey felspathic slates
	"	2. Grey and black hard siliceous shales.
Purple sandstones..........	"	3. Grey sandstones.
	"	4. Red and green slates and diorites.
Grey petrosiliceous beds....	"	5. Dark red felsites.

The passage of Divisions 3 and 5 of the Mascarene series into the sandstones and petrosiliceous beds of the Upper Silurian at Oak Bay, and the discovery that the Pembroke fossils belong to Division 3, and perhaps lower beds, shows that the Mascarene series is nothing more than the Upper Silurian strata under a peculiar aspect, resulting from the beds being deposited in shallow water, and from the mingling of lava and volcanic ashes with the higher beds.

The Mascarene series of Upper Silurian age.

We have the honor to be,

Sir,

Your obedient servants,

L. W. BAILEY,

GEO. F. MATTHEW.

FREDERICTON, NEW BRUNSWICK,
March, 1875.

SECOND REPORT

ON

THE BORING OPERATIONS

WITH THE DIAMOND DRILL,

AT NEWCASTLE BRIDGE, QUEEN'S Co., NEW BRUNSWICK,

BY

R. W. ELLS, B.A.

ADDRESSED TO

A. R. C. SELWYN, Esq., F.R.S., F.G.S.,

DIRECTOR OF THE GEOLOGICAL SURVEY OF CANADA.

SIR,—According to my former report on the progress of boring at Newcastle Bridge, the depth reached, at the time of my leaving the drill to continue my work of exploration, was 190½ feet; the last core brought up being a grey Coal Measure shale. From the occurrence of thick beds of Lower Carboniferous red conglomerate (with dolerite), about three and a half miles north of the place of boring—the strata of which were almost horizontal, the slight dip being to the south—we had estimated the thickness of the Middle Carboniferous beds at this bridge to be about 200 feet, and supposed we would strike the red conglomerate at that depth. On resuming work, which had been interrupted about two weeks, by the necessity of procuring a new bit from New York, the boring proceeded at an average rate of eight feet per day, and, at the depth of 217 feet 5 inches, passed through the Coal Measures entirely, striking not the red conglomerate as we had expected, but a series of grey and blue slates. In the Report of Progress for 1872-3, page 208, an extensive exposure of slates, probably Devonian, is noted as occurring on Coal Creek. This we traced up the stream, nearly with the strike, for over eight miles, finding the general dip to be S. 20° E. < 70°. The

Average speed.

Slates underlying the Coal Measures.

exposure is nearly twelve miles east of Newcastle Bridge, and the strike of the slates would carry them under the Newcastle area. The boring proceeded in these slates 149 feet 3 inches—the total depth reached being 366 feet 9 inches. The various bands passed through are very like those showing to the eastward, and lead to the inference that this great mass of argillites, whose outcrop shows at several points to the south, as at the North Fork of Canaan River, and at Canaan River itself, underlies all this coal-field of Grand Lake, forming ridges and knobs that occasionally protrude through the horizontal sandstones of the area, and intervening basins of unknown depth, filled with Carboniferous sediments. These sediments consist of thick beds of grey and purple sandstone and shale, which are often interstratified with beds of coarse grey conglomerate, having at the Newcastle area a uniform southerly dip, at a very low angle; so low indeed, that the coal seam of Newcastle Bridge reaches the shore of the lake about four or five miles to the south, descending in that distance not more than 40 feet. On the south of the River St. John, the beds have a similarly low dip, but to the northward.

Total depth reached.

Carboniferous rocks.

On reaching the depth of 366 feet 9 inches, the Directors of the company in charge of the drill were persuaded that further efforts to obtain coal in that locality would be unsuccessful, and the boring was stopped.

Boring stopped at 366 feet 9 inches.

Another company was, however, at once organized, and commenced operations in the latter part of the summer, at a point a little more than two miles south of boring No. 2, and nearer the shore of the lake. After some time spent in selecting a suitable rock bed, for a start, work was begun at an elevation about 50 feet higher than No. 2. The engineer was instructed to take samples of the borings, as they were obtained. The sinking proceeded quite rapidly, and reached a depth of 399 feet, 3 inches, striking the slates at a depth of 260 feet 8 inches, which, with the allowance for the difference of level at the points of starting, would give about the same thickness for the Carboniferous formation as at the Bridge. A noticeable difference in the character of the rock was observed, with the fact that while at the bridge the entire depth of the Coal Measures passed through consisted of grey beds, at this third hole there were thick beds of reddish and purple shale and sandstone, exactly similar to those observed in the lower part of the shore of the lake. In this case also, no Lower Carboniferous was met with, the Coal Measures resting directly on the slates. The time occupied in putting down this hole was about six weeks, and the borings were examined by me on several occa-

New company organized.

Depth of boring No. 3.

Time occupied in boring.

sions. This company also renounced the idea of finding any lower seam of coal in the Newcastle area, and the boring was abandoned.

Clones district. The hope of finding lower seams at this place being given up, the Government decided to bore in the Clones district, south of the River St. John, on the property of Dr. W. S. Harding, where coal had also been discovered, as well as iron ore. (See Report for 1872-73, page 217). This spot was yet nearer the contact with the Lower Carboniferous than that at Newcastle. The drill was removed to the south side of the river in the summer of 1874, and while waiting till a roadway could be prepared for its being taken to the spot selected, boring operations were commenced in August, on the bank of the Otnabog River, where it is crossed by the Georgetown Road, at a distance of eight miles from Georgetown. Boring near the Otnabog River. This boring reached a depth of not quite 200 feet, in which about 140 feet of coarse, grey conglomerate was passed through. The drill having got out of order, it became necessary to send it to St. John to be repaired, and this locality was abandoned, without reaching the bottom of the formation. After being repaired, the drill was removed in October to its destination in Clones, and located on one of the streams at the head waters of the Nerepis River. Boring in Clones. A new engineer has been appointed, and the work is still progressing in that locality. As this spot is even nearer the contact of the Middle with the Lower Carboniferous, and the beds are very nearly horizontal, the boring will not be of any great value in determining the occurrence of lower beds of coal in this district.

As yet, therefore, the question of the existence of thick beds of coal in the Grand Lake district has not been satisfactorily settled, a point that can only be arrived at by boring near the centre of the basin, the holes heretofore put down being on the northern and southern edges. Wrong situation of bore-holes. On being consulted at the termination of the Newcastle Bridge boring, our advice was to bore a series of holes—say four—across the centre of the basin, which would test it pretty thoroughly. If this could not be done, at least a test hole should be bored where the formation has the greatest apparent thickness. This has always been our advice to the Government there, as well as to the Directors of the several companies who have had the matter in charge. Hitherto, however, it has not been followed, and though the non-occurrence of lower beds of coal in the Newcastle area, which has long been a doubtful point, has been thoroughly established, there is a possibility that in the intervening basin a greater thickness of Coal Measure rocks and of beds of coal may be found which may be of great value to the Province. Possibility of finding thicker seams of Coal. The present railway policy of the New Brunswick Government will probably, during the next few years, lead to the construction of some hundreds of miles of railway, and in this connection alone the discovery of new seams of coal becomes a question of very great importance. There are many places which require careful exploration by boring besides Grand Lake, and it is but fair to suppose that in a coal area so extensive as that of New Brunswick, careful search may lead to the discovery of some seams that may yield profitable returns, and that may prove a greater inducement for the investment of capital, both home and foreign, than the present working at Grand Lake now affords.

Appended are records of the borings, showing the strata passed through, and, in the case of No 2, the time employed in boring.

I have the honor to be,
Sir,
Your obedient servant,
R. W. ELLS.

GEOLOGICAL SURVEY OFFICE,
MONTREAL, *April*, 1875.

RECORD OF BORING No. 2.

AT NEWCASTLE BRIDGE.

(See Report of Progress, 1872-73, *p.* 237.)

1873.		FT.	IN.
Feb. 17.	Flaggy grey sandstone	4	0
“	Fire clay, grey shale and sandstone	2	3
“	Grey sandstone and fire clay	1	0
“	Yellowish-grey sandstone, (micaceous)	3	2
“	“ “ “ (fine grit)	2	3
19.	Fine grey sandstone, (micaceous)	1	0
“	Yellowish-grey sandstone and fire-clay	10	8
“	Grey conglomerate	1	3
“	Yellowish-grey sandstone, (micaceous)	2	0
“	Dark grey “ “	1	3
20.	Grey conglomerate	1	2
“	Grey sandstone	1	0
“	Grey conglomerate	1	0
March 14.	Fine grey sandstone	5	5
15.	Coarse grey sandstone	20	6
16.	Fine grey sandstone, the last two feet containing fossils and iron pyrites	18	9
17.	Grey shale	6	4
“	Grey sandstone, (micaceous)	1	3
“	Grey shale “	3	5
18.	Grey sandstone	1	0
“	Grey conglomerate	1	3
19.	Fine grey sandstone	18	9
20.	Coarse quartz grit	2	5
21.	Grey shale	2	0
“	Grey sandstone	3	6
22.	Dark grey shale	4	0
“	Fine-grained grey sandstone	6	4
“	Shaly grey sandstone	1	8
“	Fine shale	7	7
24.	Fine grey sandstone, micaceous and pyritous, with seams of fire-clay	5	4
“	Fine grey sandstone	9	3
“	Fine grey sandstone, fossils and iron pyrites.	4	7
25.	Coarse grey sandstone	3	3
“	Coarse grey sandstone, with fossils, iron pyrites, and a band of conglomerate	1	9
April 11.	Greenish-grey sandstone, very fine	8	4

		FT.	IN.
April 12.	Greenish-grey sandstone, very fine (micaceous)..............................	9	6
14.	Coarse grey grit....	10	5
15.	Fine dark grey sandstone..................	5	3
16.	Grey conglomerate........................	1	0
"	Grey shale............................	1	8
May 2.	Grey shale	2	9
3.	Grey conglomerate	11	11
5.	Grey coarse grit and conglomerate...........	6	3
6.	Grey micaceous slates, with quartz veins	9	4
7.	" " " " "	6	3
8.	Fine " "	8	6
9.	" " " with iron pyrites.......	8	3
10.	Dark reddish slates.......................	8	2
12.	Grey shaly sandstone..........	5	6
14.	" slate with quartz veins	9	0
15.	" " " "	9	0
16.	" " " "	9	2
17.	" " " "	1	3
19.	" " " "	7	7
20.	Olive green slates.........................	9	0
21.	Grey slates, with quartz and calcspar.........	8	4
22.	" " (micaceous)	8	0
23.	" " "	9	0
29.	Bluish slates, "	4	0
30.	Bluish-grey slates, (micaceous).............	9	0
31.	" " " with iron pyrites...........	8	0
June 4 & 5.	Grey slates.............................	6	0
6.	Dark grey slates..........................	6	0
	Total depth reached..................	366	9

R. W. ELLS.

RECORD OF BORING NO. 3.

(1873.)

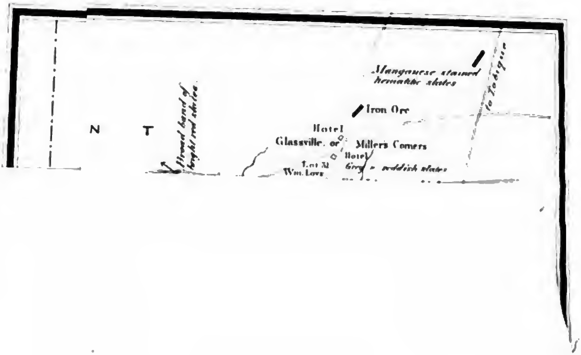
	FT.	IN.
Soil	2	0
Grey micaceous sandstone	45	0
Grey coal shale and fire-clay	8	6
Red clay	3	3
Brown and red shale	22	6
Grey sandstone	1	3
Red clay and shale	2	1
Grey shale	8	1
Grey sandstone	8	9
Black shale		3
Grey shale	4	2
Grey sandstone	6	6
Brown shale	20	6
Brown and grey shale	16	10
Grey shale	20	7
Red and grey shale	10	7
Grey micaceous sandstone	36	7
Purplish-grey sandstone	43	3
Hard grey sandy slate	2	7
Blue slate, with quartz and calcspar	37	1
" " "	98	11
	399	3

The borings in this case were collected by Mr. L. C. Wallace, the Engineer in charge, and examined by me.

R. W. ELLS.

fap.

ron ore.


Manganese stained hematitic slates
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Broad band of bright red slates
Hotel
Glassville, or Millers Corners
Hotel
Lot 31
Wm. Love
Grey & reddish slates

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REPORT

ON THE

IRON ORE DEPOSITS OF CARLETON COUNTY, NEW BRUNSWICK,

BY

R. W. ELLS, B.A.

ADDRESSED TO

A. R. C. SELWYN, Esq., F.R.S., F.G.S.,

DIRECTOR OF THE GEOLOGICAL SURVEY OF CANADA.

Sir,—It being deemed advisable to make a somewhat detailed survey of the Iron deposits of Carleton County, New Brunswick, for the purpose of determining their extent, I, in accordance with your instructions, proceeded to Woodstock on the 1st of May last, and as a preliminary step, in order to fix accurately the different localities where iron ore occurs, made as complete a topographical survey as was possible under the circumstances (it being impossible to take advantage of the streams, owing to the high state of the water) of the country between the St. John River and the State of Maine, and extending along the river from Woodstock to Florenceville. The measurements were made in great part with the odometer, additional details being filled in by careful pacing. A map showing all known outcrops of iron ore, and such further information as I could gather of the country visited, has been constructed on a scale of two and a half inches to the mile, and reduced to a scale of two miles to the inch. In order to shew the exposures of iron ore that exist east of the river, I have enlarged Wilkinson's Province Map of that part of the country, as I had not time to make a topographical survey of it.

Map.

The outcrops of iron ore, as will be seen by the map, are quite numerous, extending in a general north-east course from Campbell's Corner, near Jacksonville, to Flanigan's Hill, on the River St. John. The ore is found in a series of hills, with an average height of about 300 feet above

Iron ore.

Jacksonville.

the wharf at Woodstock. These, in the vicinity of Jacksonville, are known as Moody's Hill, Iron Ore Hill, Maple Hill and Flagstaff Hill.

Beginning near Campbell's Corner—at Moody's Hill—we find four openings, three of which are of considerable size, and have yielded a quantity of iron ore, amounting in all to about 20,000 tons. The lowest opening on the slope of the hill is Adam Carnie's. Here two beds of ore are exposed—one of one foot and a second of three feet in thickness. The ore is a rich looking, compact hematite, embedded in dark rusty slates, dipping W. 33° N. <85°—90°. The second opening—Theodore Carnie's—is a quarter of a mile N. E. of the first, and near the summit of the hill. Here the containing beds are red and green clay slates, the red slates being strongly charged with hematite, and all very much twisted. This bed of ore is of unequal width, ranging from five to fifteen feet, and a large quantity of ore has been removed from it. Opening No. 3, Hamilton Emory's, is 320 yards W. 20° N. from No. 2, and in a bed the course of which is W. 30° S., and the thickness about nine feet. The opening extends for about seventy yards along the strike. The containing rock is a blackish slate, with veins of quartz. None of these beds of ore have been worked to a greater depth than twelve feet. There is another opening on the strike of the Emory bed, further to the N.E., but it is of very small size. The height of Moody's Hill above Woodstock Wharf is 280 feet by barometer.

Iron Ore Hill.

Iron Ore Hill is the chief place from which the ore used in the Woodstock furnaces was taken. Here there are a great number of ore beds. The containing rocks are very fine, dark red and green, micaceous slates, stained black on weathered surfaces, probably from the presence of manganese. The faces of the beds of ore are in many places slickensided, and exhibit much iron pyrites in crystals and masses. Small veins of calcite also occur, and the ore is often very calcareous, and associated with considerable quartz. The slates are very strongly charged with oxide of iron, and hold numerous small concretions. The course of the ore beds is very irregular, following the twistings of the slate; it varies from N. 37° E. to E. The slates have a pretty uniform dip, where not contorted, of N. 45° W. < 85°. The veins or beds of ore vary from one to sixteen feet in thickness, and have not been worked deeper than twenty feet. About 50,000 tons of ore have been extracted, the principal openings being about twelve in number, though there are as many more smaller ones.

Proceeding northward the next exposures are on a hill about midway between Iron Ore Hill and the Jacksontown post office. The first opening is Good's, or Everett's. Here the ore is from six to twelve feet in thickness, with a strike of N. 20° W. It is a red hematite, like the last, and appears to be a rich ore. 700 yards N. W. from this is the Stevens Mine, where several openings have been made, but no regular mining done. On the western slope of the hill, half a mile north of Everett's Mine, is Kimber's Mine, from which a considerable quantity of ore has also been taken.

Going north, the next opening is near the Jacksontown post office, and is known as Palmer's Mine. Here the ore is blacker and heavier than much of that previously noted, containing apparently more manganese; the associated slates have a dip of W. 30° N. < 90°. The ore beds are crooked and apt to run out suddenly, and vary from eight to fourteen feet in thickness. On the crest of the hill, about ten rods to the south of the opening, is a ledge of conglomerate, composed of fragments of slate and limestone, cemented by a calcareous paste. Imperfect remains of crinoid stems could be observed in the limestone pebbles, but were so indistinct as to be worthless for determination. From this opening about 200 tons of ore have been taken, which, according to Mr. Palmer, was nearly one-twelfth heavier than the average of that from Iron Ore Hill. This last opening is five miles north of the foundry at Upper Woodstock.

Fossils.

Still going north, on the road to Williamstown, we pass frequent exposures of red and green slates, and at a distance of two miles, on the lot of Mr. Jarvis Easty, on Flagstaff Hill, several outcrops of ore are found. The slates here are bluish-grey and calcareous, and dip W. 35° N. < 90°. As no openings have been made, we could not determine the thickness of the deposits, but there seems to be a large quantity of the ore, much of which is very hard and black, differing in appearance from that of the other localities, and containing a good deal of manganese. A specimen examined for phosphoric acid gave 2·45 per cent.

Flagstaff Hill.

North of this, no more exposures of iron ore are seen till we reach Flanigan's Hill, on the River St. John, eighteen miles above Woodstock. Here there are thick beds of red slate, and on the southern slope of the hill many loose pieces of iron ore were seen. The bed from which they were derived was covered over at the time of our visit, although it had been opened up previously by exploring parties from the Woodstock foundry. The ore is stained black, and resembles that of Jacksontown. On the slope of the hill, there is a very good quarry, from which the stone for the railroad bridge over the Beccaguimic was obtained. The rock of the quarry is the usual grey calcareous slate, and although it is much contorted, it splits out in quarrying into fine blocks of good size.

Flanigan's Hill.

Building stone.

The quarry is only about 800 yards from the bank of the river, and will no doubt be valuable. The red slates of Flanigan's Hill with their associated iron ore were traced across the river at this point by Mr. Robb.*

Following the strike of the slates south-west from the principal deposits in Jacksonville, we find at a point on the main road between Woodstock and Houlton, about one mile east of the boundary, another outcrop of hematitic slates; the ore, however, is in small quantity where exposed, but it is stated that there is a large deposit on the same strike in the State of Maine, about two miles south of the town of Houlton. This deposit has been referred to by Prof. Hitchcock in his report on the Geology of Maine, and the ore said to be similar to that of Jacksonville.

ed conglomer-
:e.

Near the town of Woodstock, the grey calcareous slates of the iron district are bounded on the south by a hard, greenish, crystalline rock, which in some places weathers rusty, and in others white or grey. It is much intersected by veins of quartz, and in several places appeared to dip W. 35° N. < 70°. Masses of this greenish rock shew through the slates in several places, as in the river below Florenceville and in Mount Delight Settlement. The line of contact could not be seen, being overlaid above Woodstock by a mass of red ferruginous conglomerate, consisting of pebbles of quartzite in a deep red calcareous paste, which contains 7·86 per cent. of peroxide of iron. The conglomerate shows for a breadth of 300 yards at the foundry, but apparently runs out about 600 yards south, just crossing the Jacksontown road. It can be readily traced by the red colour it imparts to the soil, as well as by its frequent exposures, and extends nearly to Victoria Corner, ten miles above Woodstock. It has a dip of N. 45° W. < 45°—50°, conforming in strike with the slates and quartzites that bound it on either side. As it has a much lower dip than either the slates or quartzites, and runs out just by the village of Upper Woodstock, it would seem to have the character of a shallow basin resting unconformably on the older rocks. In his report on Maine, Professor Hitchcock, who examined the locality briefly, has expressed this view. The red paste of the conglomerate was used to some extent as a flux in the smelting of the hematites of Jacksonville.

On the east side of the River St. John, several exposures of iron ore have been noted. An examination of this part of the country was made by Mr. Edward Jack, of the Crown Lands Department, and myself, and specimens obtained from all the localities that were accessible. The first exposure of red and green slates, on the east side of the river, noted by us, occurs near the junction of the Lower Newburg Road with the River Road. Mr. Jack found indications here of a deposit of hematite, which, however, is probably unimportant. The associated rocks are of a quartzose nature. Passing up the River Road, at the mouth of the Little Pokiok, just below the mouth of the Beccaguimic River, is a large exposure of a coarse grey conglomerate, stained with manganese, which has already been noted by Mr. Charles Robb* in his report on this locality, and traced by him on its extension eastward. It is, as he says, the probable continuation of the red Lower Carboniferous conglomerate band seen on the other side of the river, and terminating nearly opposite. Passing this, calcareous slates are the prevailing rock, interstratified, however, in many places with beds of rather coarse greenish sandstone, somewhat resembling diorite in appearance. Leaving the main River Road at the village of Hartland, the road to Glassville runs up along the south bank of the Beccaguimic River, and on lot No. 2, occupied by Jas. Thomas, the beds of red hematite are again seen. The ore occurs here in small veins, three in number, from one to two feet in thickness, and very black on weathered surfaces. In connection with this bed is a very curiously banded limestone, containing about eight per cent. of iron and a large proportion of manganese. The enclosing slates are of the usual red and green colours, and calcareous like those of Jacksonville. They dip N. 35° W. < 85°, and their strike would carry them across to the principal deposits of Jacksonville, so that they are probably a continuation of those beds.

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* See Report of Progress 1866-69, page 199.

Calcareous slates.

Going up the Beccaguimic River road, we found the next exposure at the fork of the Coldstream and the Beccaguimic. The ore, which occurs here just at the roadside, was traced on its strike for a distance of nearly a mile, showing a width of from three to four feet. In character it is similar to that on the Thomas lot, and a band of manganesian limestone is also associated with it; as it is directly on the strike of that last noted, it is probably a continuation. There seems to be an abundance of ore at this place. Its quality has not yet been tested; but, if free from phosphorus, it would be most valuable for mixing with the other harder ores. No other exposures of hematite were met with on the road to Glassville, though there are numerous bands of red and green slate, and occasional interstratified beds of greenish dioritic-looking sandstone.

Manganesian limestone.

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* See Report of Progress, 1866-69, p. 197.

Miller's Corner.

At Miller's Corner, Glassville, as was formerly conjectured by Professor Hind, the hematites are again exposed on lot 31, which is owned by Wm. Love. Numerous blocks of ore are found on the slope of the hill, which must be from a bed of considerable size; the exact thickness, however, could not be ascertained, but the outcrop was seen in places by Mr. Jack on a former visit. This bed crosses the road from Shiktehawk to Miramichi River near the Corner, and re-appears on the north side of the road. Another exposure was reported on the cross road to Tobique River, about two miles east of Miller's Corner, on the property of Wm. Hayes, who found it while digging a well; but this was filled up when we were there, and no trustworthy details concerning it could be obtained.

Manganese.

Going west from Miller's Corner, on the road from Glassville, to the mouth of the Shiktehawk, about one mile and a-half west, there is a thick, calcareous band crosses the road. The quantity of iron in this, however, is small, not exceeding nine per cent., although there is over twenty per cent. of manganese. A little further west this bed is followed by a large belt of bright red slates, having the usual north-westerly dip. Half way between Miller's Corner and the River St. John, the greenish sandstone occurs in large ledges, and appears to form high hills to the south, being succeeded again to the west by calcareous slates.

Pole Hill.

In the parish of Brighton, at Pole Hill, the so-called ores have been seen by Mr. Jack, and are pronounced by him similar to those of the Beccaguimic. No complete analyses have been made of those from this side of the river, but simply determinations of iron. These gave for the specimens from the Thomas lot only eleven and a-half per cent. of iron. The beds are very calcareous, and, if free from phosphorus and sulphur, would afford valuable material for fluxes.

nalyses.

The ore beds of Jacksonville and vicinity do not seem to be repetitions of the same bed, but rather to occur in a series of parallel belts, having the same general strike and inclination. The deposits on the eastern side of the river are less compact, and contain a lower percentage of iron, with more calcareous matter. No complete analyses of any of the ores have, to my knowledge, been made, with the exception of those from Iron Ore Hill; but it is not improbable, considering the great extent of the deposits and the different character of the ores outwardly, that localities may yet be found where the beds will prove to be of better quality. While the furnace was in blast, it is stated there was a manifest difference at times in the character of the iron produced, and while in general it was cold short in a high degree, from the presence of phosphorus, some of the pigs equalled in tenacity the best Scotch brands.

Woodstock Furnaces.

Engines.

Charcoal kilns.

For the following information concerning the operations at the Woodstock Furnaces, I am largely indebted to David Munro, Esq., of Woodstock, as well as to my own observations. The location of the works is on the south side of Lane's Creek, at its junction with the St. John River, and just above the village of Upper Woodstock. Here there are several terraces, and the furnaces were so built that their tops were level with the second terrace, the charges by this means being dumped in at the tunnel head without the expense of hoisting. The first furnace erected was thirty-seven feet high and thirty-three feet square at its base, having three twyer arches, built of Gulquac sandstone with Stourbridge lining. The size of the crucible was three feet six inches by four feet, and six feet high; the furnace was nine and three-quarter feet in diameter at the boshes, and the twyers were two feet above the bottom of the crucible. The capacity of this furnace was seven tons per day. Later a smaller one was built, enclosed in boiler plate, having a circumference of forty feet, and a capacity of five and a half tons per day. This is lined with Stourbridge bricks. There were two high-pressure engines, with cylinders sixteen inches in diameter and four feet stroke, of twenty-six nominal horse-power; two blowing cylinders, six feet by five, with an air receiver, twenty-eight feet by four feet ten inches. Steam was generated in five boilers, twenty-eight feet in length by three feet three inches in diameter, and was maintained by the waste gas from the head of the furnace. The fuel used was chiefly hardwood charcoal, from maple, birch, and beech, yielding at the kilns forty-five bushels of charcoal to the cord of wood. The cost of the wood at the kilns is about $2 or $2.50 per cord. There were ten charcoal kilns, with an average capacity of seventy-five cords of wood, and a production of 2,800 to 3,200 bushels of coal. The quantity of ore used was, on an average, three tons to the ton of pig, and the cost at the furnace $1.20 per ton. One hundred and twenty-six bushels of charcoal were required per ton, at a cost of seven cents per bushel, and the cost of pig produced was $20 to $22 per ton. Much delay and expense has occurred by the frequent stoppage of the furnace for repairs, which were deemed necessary every four or five months, keeping the furnace idle about two months in the year. *

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* The operations at the Woodstock furnaces have already been described by Dr. Harrington, Report of Progress, 1873-74, p. 281.

Analyses by Mr. Mitchell.

The average of six analyses of ore from Iron Ore Hill, made by John Mitchell, Esq., of London, gave:—

Metallic iron	35·593
Sulphuric acid	·723
Phosphoric acid	1·298

Analyses by Mr. Wendt, M.E.

An analysis of the pig, by Mr. Wendt, M.E., a graduate of the Columbia School of Mines, lately connected with the antimony mines at Prince William, gives: phosphorus 1·032, sulphur ·005, manganese 3·460, iron 93·08. It is to be regretted that some of the samples of ore from other localities have not been analysed.

The ores occur at a distance of only a few miles from the furnaces, the descent to which from the mines is easy and gradual. The Riviére du Loup Railroad, moreover, will afford additional facilities for the development of the mines, as no difficulty will be experienced in sending away iron at any time, or in transporting fuel and flux to the furnace. Under these circumstances it is to be hoped that with a proper selection of the ores successful results may yet be obtained at Woodstock.

I have the honor to be,
Sir,
Your obedient Servant,
R. W. ELLS.

GEOLOGICAL SURVEY OFFICE, MONTREAL,
April, 1875.

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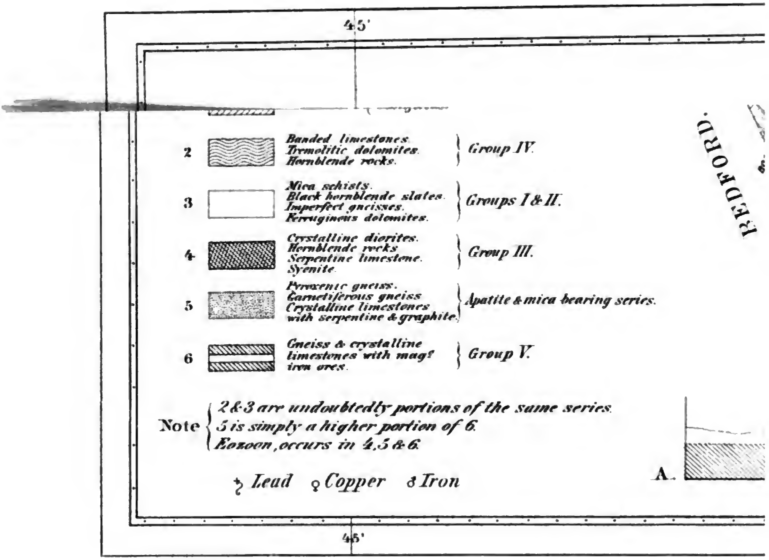

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PROGRESS REPORT

OF

EXPLORATIONS AND SURVEYS IN THE REAR PORTIONS OF FRONTENAC AND LANARK COUNTIES,

TOGETHER WITH

NOTES ON SOME OF THE ECONOMIC MINERALS OF ONTARIO.

BY

HENRY G. VENNOR, F.G.S.,

ADDRESSED TO

ALFRED R. C. SELWYN, Esq., F.R.S., F.G.S.,

DIRECTOR OF THE GEOLOGICAL SURVEY OF CANADA.

Geological map.

SIR,—As you directed, I continued my investigations last summer in the townships in the rear portion of the County of Lanark; namely, North Sherbrooke, Dalhousie, Lanark, Ramsay, Levant, Darling and Pakenham, through which I succeeded in tracing out the distribution of the more important bands of rock. These explorations have enabled me to form a tolerably complete geological map of the whole of Lanark County, from the waters of the Rideau on the south, to within a short distance of the Madawaska River on the north; excepting, however, portions of the townships of Darling and Pakenham which were inapproachable, owing to the extensive bush fires which raged there through the whole of the summer of 1874.

Preliminary operations.

Before commencing work in the rear of Lanark County, I spent some time in making additional surveys and corrections in a portion of the township of North Burgess, which were necessary for the small map accompanying my report for 1872-73; in enquiring into the cause of the cessation of work at the apatite mines; and in re-examining the iron ore deposits of South Sherbrooke, North Crosby and Bedford, now rendered

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more accessible by the approach of the Kingston and Pembroke Railroad, which is said to be graded as far as the Narrows of Sharbot Lake, in the township of Oso. On the completion of my surveys in Lanark, and towards the close of the season, I went westward to the Addington Road, in Addington County, and completed a general section of the rocks, from the red granite area of Anglesea to the granite or gneiss area, known as the " Bald Mountains," in Sheffield township, in all a distance of about twelve miles, and further examined the country along the east side of the Salmon River, on the eastern flanks of these " Mountains," between the villages of Tamworth and Arden, in Kennebec. These surveys enabled me to connect those heretofore made by Mr. Alexander Murray with my own, and to determine the geological horizon of the rocks mentioned by him in his report for 1852-53, pages 100 and 101.

Section on the Addington Road.

Plan of investigations.

In my investigations in Lanark, I adopted a plan differing somewhat from that of former years, and one which, while it required a little more time, furnished me with far more satisfactory results. This consisted in first carefully measuring and surveying by chain and compass all the available roads and paths in each township, noting all prominent objects, such as houses, bridges, swamps, intersections of creeks, rivers, and boundaries of ponds and lakes, also all lot and concession lines; in short, to make as correct a topographical, but not geological, plan of each township as was possible. This work was plotted to the scale of twenty chains to one inch, and afterwards inked in on a number of sheets of paper. With these sheets in hand, I again went carefully over the same ground, devoting my whole attention to the geological structure of the respective sections, and sketching in with colours the outlines or boundaries of every band of rock; also making additional offsets from fixed points, by means of an odometer or the chain, to other points of importance, such as openings, veins and escarpments, lying between the mapped roads. Thus before commencing surveys in a second township, I had a complete geological plan of the first, and the clue thus obtained to the structure necessarily much facilitated future working.

Extent of measurements.

The measurements thus made in the seven townships, which constitute the rear part of Lanark County, together with those through portions of Bathurst, South Sherbrooke, Oso and Palmerston, to connect with previous work, and on the line of section in Addington County, amount in all to over one thousand miles; the whole of which have been reduced to the scale of four miles to one inch, and fitted to their respective townships on the outline map which accompanies this report. Respecting this map, I have further to state, that it has been prepared with a special view to the clear illustration of the geological structure of the whole of Lanark County, and will consequently render unnecessary the usual length of text otherwise required to explain intelligibly the sinuosities of the various outcrops of rock. This will be followed, in a subsequent report, by a much more complete and detailed topographical map, now in course of preparation by Mr. Robert Barlow, Draughtsman to the Geological Survey, which will embrace, besides Lanark County, all the country lying between it and Hastings, and as far southward as the River St. Lawrence. This last map would have been ready for the present Report had not the incorrect surveys in several parts of the Counties of Addington and Frontenac required further time for adjustment.

Map in preparation.

The result of the season's work may be considered under the following headings:—

I. Map of North Burgess.
II. Cessation of Work at the Apatite Mines.
III. Iron Ore Deposits of Lanark, Leeds and Frontenac, and the Kingston and Pembroke Railroad.
IV. The Geological Structure of the Rear Portion of Lanark County.
V. Gold, Copper, Galena and Plumbago.

I.

MAP OF NORTH BURGESS.

The map of the township of North Burgess, which I carried with me into the field during the summer of 1873, was one taken from a tracing in the Registrar's office, in the town of Perth, said to be a correct copy of the map in the office of the Crown Lands Department. It was one of those straight-ruled, equally-divided plans, which suggest at first sight a suspicion of incorrectness, at any rate respecting lot and concession lines, and a very few days of field-work sufficed to prove its utter uselessness as a guide to the topography of the country.

The only other map obtainable was one published in 1863, by D. P. Putnam, of Prescott, Ont., from surveys made under the direction of H. F. Walling, embracing the whole of the counties of Lanark and Renfrew, in which many of the townships had been carefully corrected and most of the roads re-surveyed and measured by the odometer. This map furnished me with a small, but tolerably correct, plan of the township of North Burgess, which I used during the summer of 1873, while engaged in mapping the general geological structure of this and adjoining townships. During the past summer, however, for the purpose of placing in their proper position a number of the more important of the openings made for phosphate of lime, I found it necessary to re-survey a considerable portion of the easten part of this township, and to correct the delineation of several of the lakes. These surveys and corrections were made in time to accompany my report for 1873-74, and are embodied in the plan of North Burgess there given.

II.

Cessation of Work at the Apatite Mines.

Mining operations on lot 10, range 6, of North Burgess.

While in North Burgess last summer, I could not but be struck by the general inactivity which prevailed on all sides in regard to the mining of apatite, and I was led to make some enquiries as to the cause or causes of this almost entire suspension of work. I found that the only location in this township which was being systematically worked, was that on the tenth lot of the sixth concession (Number 8 in the list of locations, Report of Progress 1871-72, p. 124). Apatite was still being mined here by Mr. B. Anthony, for Floerstein & Co., an English Company which had purchased the property from its former owner, Mr. E. Clark. Besides a number of smaller openings, two shafts have been sunk to depths of 135 feet and seventy feet respectively,* over each of which a house has been built. Small engines are employed to raise the ore and pump out the water. The thickness of the veins or beds is very variable; that in the deepest, or No. 1 shaft, varies from six inches up to as many feet, and at the bottom the side walls appear to me to be coming together. The vein in the second, or seventy feet shaft, does not often exceed eighteen inches, and at the bottom has almost entirely thinned out. A very large amount of apatite, above the average quality, has, however, been raised from these two shafts, and shipped to England. It was remarkably free from foreign matter, and of a much higher average percentage than any that has hitherto been exported from the township. Mr. Anthony had also established a neat and commodious laboratory in connection with his mines, and a chemist was employed in making tests or frequent analyses of the mineral as the work progressed. At the time of my visit, however, I found that even here work was shortly to be suspended, Mr. Anthony having received instructions to that effect from England, and on a second visit, later in the season, I found the men had been discharged, the buildings closed, and that everything was at a stand-still. The stoppage of work at these mines, and the withdrawal from North Burgess of Messrs. Morris and Griffin, of Wolverhampton, England, and of Mr. Edward Schultze, a German exporter, and others, has been a great damper to the mining enterprise throughout the whole of this section of country, and will undoubtedly, at least for some time, put an end to all attempts to mine apatite for export to either Britain or the Continent of Europe. The only other location in which any work was in progress was that on lots eleven and twelve in the seventh concession of North Burgess, (No. 7 of the list of locations, Report of Progress 1871-72, page 124.) Here, on property owned by Mr. A. Cowan, of Brockville, apatite was being raised by contract work by Mr. Gerald C. Brown, (formerly mining captain at the Dalhousie iron mine, in Dalhousie township) the greater bulk of which was for the supply of Mr. Cowan's superphosphate works at Elizabethtown, near Brockville. On this location a considerable quantity of apatite was raised during the season, amounting perhaps to between six and eight hundred tons, but the quality was in most cases far inferior to what had been obtained on Mr. Anthony's lot. Much of it was stained a deep red colour from the presence of earthy red hematite, and in places this ore itself occurred in detached fragments or broken layers in the apatite. Pyroxene and mica were also abundantly disseminated through the apatite, and piles of this mixture, which were probably not worth removal, were observed around the mouths of several of the pits. The openings on these lots of Mr. Cowan's are numerous, but most of them were made several years back, and have since been abandoned. A few are deep, but the remainder consist of shallow pits and trenches. As already mentioned, the mining here was carried on by contract work, and the apatite was extracted at a cost not exceeding $9.00 per ton, a price which leaves ample margin for profit. There can be but little doubt that if more of the mining operations in North Burgess, and elsewhere, had been carried on by contract work, instead of by the costly methods hitherto resorted to by most of the English companies, we should not now have to report such utter failures as those of the past few years. Outside of North Burgess, excepting some desultory mining by private parties in the eleventh concession of Loughborough, near Bedford, and in proximity to Sydenham village, nothing worthy of note has been accomplished, although numerous new discoveries are reported in many parts of this township. In fine, then, I may safely state that, at the close of

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* These shafts and openings are shown on the map which accompanies the report for 1873-74.

Lots 11 and 12 in the 7th concession.

Cost of mining.

the summer of 1874, the mining for phosphate of lime in this whole section of country was confined to the contract work of Mr. Brown, for Mr. A. Cowan, already mentioned, on lots eleven and twelve of the seventh concession of North Burgess, and to some superficial work on one or two lots in the township of Loughborough.

Cause of cessation of apatite mining.

A few remarks may here be made respecting the cause or causes of this almost complete cessation of apatite mining. And first, I would clearly state, that it is not from—to use a common miner's term—any "giving out" of the mineral, as the contrary is the case. For there is at present more visible encouragement to apatite-seekers throughout this whole field than has ever yet existed, and new discoveries are being made daily. But apatite is, comparatively speaking, a cheap mineral, and consequently must be cheaply mined. The first purchase of lands or mining leases must be low, machinery, buildings, &c., must be of the most economical construction, salaries of foremen and wages of men must be moderate. Such being undeniably the case, we have only to contrast with this the recent operations in North Burgess to arrive at the true cause of the present abandonment of these mines. First and foremost we may mention the wild and extravagant prices in many instances paid for lands and mining leases, the erection of costly and often entirely unsuitable machinery at the mines, the injudicious method of mining, and last, but not least, the high pay received by mining captains or foremen, and men, many of whom were brought out from England to work in these mines. When we add to the above the extremely high rate of freight for cargoes of this description during the past few years, we cannot for a moment express surprise at the result.

Success of private individuals.

But while the attempt to mine apatite extensively for export to Europe has been everywhere attended by so complete failure, there are those who, mining on a smaller scale and in a less extravagant manner, have reaped a rich harvest. I refer here to a number of private individuals in several parts of the country who have raised considerable quantities of apatite at comparatively small cost, and have sold it at most advantageous prices to English and other exporters. And this only further proves what I have already stated respecting the mining operations, namely, that in order to ensure any measure of success, the most inexpensive methods of mining must be resorted to. One other mistake should here be mentioned, and that is the attempt at *deep* mining. In this Mr. Anthony has decidedly failed, and so have a number of others.

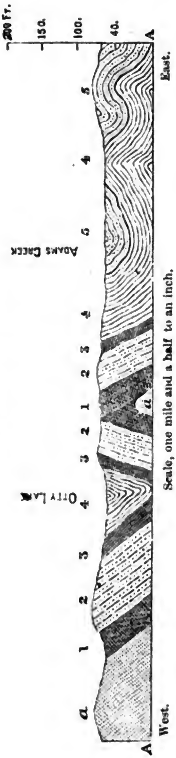
Superficial character of apatite deposits.

There can now be no manner of doubt that these deposits of apatite are of a comparatively superficial nature. By far the greater number of those already opened have attained their greatest proportions at or within a short distance from the surface, and have diminished rapidly in descending. The whole geological structure of North Burgess and Loughborough demonstrates the shallow basin-shaped attitude of the phosphate-bearing rocks, and as the apatite chiefly occurs in these as bedded deposits, it is of course frequently brought to the surface by the undulations of the strata.

Section No. 1, will illustrate more clearly the character and structure of these deposits.

No. 1.

SECTION ACROSS NORTH BURGESS.



Scale, one mile and a half to an inch.

A. A. Level of Rideau Lake, 400 feet above the sea. *a.* Pyroxenic gneiss. 1. Lower crystalline limestone (band No. 5, Report of Progress 1873–74, p. 104). 2. Garnetiferous gneiss with apatite. 3. Upper crystalline limestone. 4. White orthoclase and pyroxenic strata with apatite. 5. Garnetiferous quartzite and orthoclase strata. (*Eozoon* occurs towards the summit of *a*.)

In the foregoing observations I have attempted to show that apatite still exists in remunerative quantity in North Burgess and Loughborough; that the mining of it for export has hitherto been a failure simply through the injudicious and costly manner in which it has been carried on; that while expensive operations have failed, private individual effort has met with marked success; and finally, that deep mining is not likely ever to prove successful in any part of this mining field.

III.

IRON ORE DEPOSITS OF LANARK, LEEDS, AND FRONTENAC COUNTIES; AND THE KINGSTON & PEMBROKE RAILROAD.

Iron ores now rendered accessible.

The opening of the Kingston & Pembroke Railroad as far as the "Narrows" of Sharbot Lake, in the Township of Oso, or to a distance of between thirty-eight and forty miles from Kingston, at last renders accessible a number of very important deposits of magnetic iron ore, which, though long since discovered, have remained for the most part unworked, owing to their remoteness from navigable waters or lines of railroad. They occur chiefly in the townships of Hinchinbrooke, Bedford, North Crosby and South Sherbrooke, and may be enumerated as follows:—

1. Eagle Lake	deposit.		Hinchinbrooke and Bedford.	
2. Howse Iron	“		Bedford.	
3. Wolf Lake	“		“	
4. Spectacle Lake	“		North Crosby.	
5. Mitchell's	“		“	“
6. Hon. G.W. Allan's	“		“	“
7. Bygrove Iron	“		South Sherbrooke.	
8. Fournier's Iron	“		“	“
9. Meyer's Lake	“	(south shore)	“	“
10. Meyers' Lake	“	(north shore)	“	“
11. Silver Lake	“		“	“
12. Gordon's	“		Bathurst[*]	

Eagle Lake Deposits.—Eagle Lake is a somewhat extensive sheet of water, situated in the north-eastern corner of the township of Hinchinbrooke, and having on the southern side a deep bay or narrow arm, which runs eastward as far as the boundary line of Bedford, between the twenty-sixth, twenty-seventh and twenty-eighth lots of the first concession of both townships. The iron ore is chiefly on the twenty-ninth and thirtieth lots of the township of Bedford, and not far removed from the shore of the lake; but there are also indications of it on the same numbered lots in Hinchinbrooke. The magnetite occurs in a bedded form, and is associated with heavy, dark, hornblendic and dioritic rocks, which in a number of instances are met with in close connection with the ores of iron in this section of country. The deposits at Eagle Lake have not been tested to any extent. Some of them were discovered during the year 1870, but, excepting a slight uncovering, nothing was attempted; and although efforts have frequently been made to draw the attention of capitalists to the locality, they have not met with much success. Recently, however, during the years 1873 and 1874, the proximity of the Kingston and Pembroke Railroad caused greater interest to be taken in this neighborhood, and additional openings were made. These revealed two or three fair exposures of magnetic iron ore on the lots which have been already named in Bedford, namely, twenty-nine and thirty in the first concession, the mineral rights of which were, I believe, purchased at a rather high figure last summer. The beds of ore here are extremely irregular, and do not appear to me to warrant much outlay, although it would undoubtedly be of great interest, should one or more of them be properly tested. The ore itself is a beautifully crystalline magnetite, yielding, according to Prof. Chapman's analysis, 62·52 per cent. of metallic iron. It contains merely traces of phosphorus, a very small amount of sulphur (0·07), and not enough titanic acid (3·23), to detract from its value. One serious drawback, however, exists in the fact that apatite is associated with much of the magnetite, both in the form of grains and crystals. The crystals are very easily separated from the ore, but the finely granular portions are so intermixed with it as to be inseparable. I have already reported on a similar association of magnetite and apatite, which exists at the "Foley Iron Mine" in Bathurst (Report of Progress, 1870–71, p. 313), where, as at Eagle Lake, it appears to characterize the lowest horizon of iron ore deposits.

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[*] Some other deposits of ore in Bathurst are not here mentioned, as they are too far removed to be affected by the Kingston & Pembroke R. R.

Mode of occurrence of the Eagle Lake ore.

Character of the ore.

I may further mention in proof of the stratigraphical arrangement of the iron ores, that the position of the Eagle Lake deposit, relatively to an overlying band of limestone, is the same as that of the Foley mine in Bathurst; and that this band of limestone having now been continuously traced from one locality to the other, a line may easily be drawn that will, in all probability, also show the course along which other masses of iron ore may be expected to occur. This line is drawn on the map accompanying the present Report, and to it I beg particularly to direct the attention of those searching for iron ore.

Line along which iron ore may be expected to occur.

There are a few other points of interest which may be mentioned in connection with this horizon of iron ore; and, first, it is not only marked or characterized by the presence of apatite, but also by the general coarsely crystalline character of the ore itself. It may be mentioned that Dr. Harrington, when describing the ore at the Foley mine in the township of Bathurst (Report of Progress 1873–74, p. 194), says: "The magnetite was found here in large octahedral crystals, the axes of which are often more than an inch in length; these crystals are somewhat rude, but their surfaces are covered with smaller ones, which, though minute, are well formed." Such is precisely the character of much of the ore at Eagle Lake, where perfect crystals of apatite were also observed imbedded in the magnetite. Dr. Harrington further states: "In the undoubted beds, the magnetite, so far as I have observed, is generally granular or in cleavable masses, but does not occur in large crystals of definite form. The mere occurrence of crystals, however, would in itself be no proof of the deposit being a vein." At Eagle Lake, the magnetite seems to occur as an unmistakeable bed, and between the Foley and Eagle Lake mines, it is found in several localities, in disseminated grains and strings, in a peculiar stratified dioritic rock, which is apparently made up of the same constituents as the more coarsely crystalline diorites with no traces of stratification. These coarse varieties of diorite occur as lenticular or irregular shaped masses at perhaps two or more horizons, and they are often unaccompanied by iron ore. Epidote characterizes portions both of the stratified and unstratified diorites, and in the former has been found arranged in alternate layers with iron pyrites and magnetite.

Resemblance to the ore of the Foley Mine.

The Eagle Lake deposit a bed.

Diorites.

It may here be mentioned that most of the diorites are undoubtedly interstratified masses. In Hastings, they are fine-grained, and here the magnetite is also very fine-grained; for example, the Seymour iron ore bed, Madoc, an ore at Downey's Rapids in the same township, the Big Ore Bed in Belmont, and many other deposits; while in the Counties of Frontenac and Lanark, where the diorites are coarsely crystalline, the accompanying magnetites are also of the same description.

The proximity of the Eagle Lake deposits to the Kingston and Pembroke Railway of course increases their value; and although the ore may not prove to exist in any great quantity, it is of such excellent quality that a good price may be expected for all that can be obtained.

New discoveries at Silver Lake.

Silver Lake Deposits.—The Silver Lake iron ores in South Sherbrooke are new discoveries, and have not before been noticed in the Survey reports. They were first observed, as far as I can find out, during the summer of 1873, but as the locality in which they occur is an uncleared and hardly passable wilderness of rock and bush, all that I then ascertained concerning them was that the specimens exhibited had been obtained somewhere in the vicinity of Silver Lake, a small and peculiarly shaped lake situated about the centre of South Sherbrooke and in portions of the fourth and fifth concessions, between lots twelve and sixteen. Later, in the spring or summer of 1874, further search was made, I believe, by Messrs. Manion and Oliver, who discovered indications of iron ore, and finally succeeded in securing the lots on which they are now working. On first hearing of the discovery in this locality, I concluded that it must be on a continuation or extension of the ferriferous belt, on which is situated the Foley and McVeigh deposits in Bathurst. This conjecture was supported by a number of miners, some of whom informed me that they had themselves traced the ore from the one to the other locality. Further examination, however, rendered this fact doubtful, and evidence accumulated to convince me that the Silver Lake magnetites were more probably on an extension of the well known iron ore beds of the northern shore of Meyer's Lake, while the iron horizon represented by the Foley mine would thus be thrown considerably to the rear of Silver Lake, or more towards Maberly Village on the Fall River. This I subsequently found to be the true stratigraphical position of the Silver Lake deposits, and this discovery threw a great deal of light upon the whole geological structure of South Sherbrooke, which, up to this time, had been very obscure.

Stratigraphical position of the Silver Lake deposits.

The deposits of magnetite occur along the southern shore of Silver Lake, on lots thirteen, fourteen and fifteen of the fourth concession of South Sherbrooke, and their true position may be seen on the map accompanying this report, on which I have also corrected the position of the lake. Openings have been made by Messrs. Manion and Oliver in all the above-mentioned lots, but sufficient work has not yet been done to enable me to state whether the various exposures belong to one or more beds. The largest opening is upon lot fifteen, and is about thirty-five feet long by fifteen deep. The strike of the bed appears to be about north-east and south-west, and the dip steep to the south-eastward. From this opening about 200 tons of ore of a very good quality have been extracted. This still lies on the ground awaiting shipment. As the Silver Lake deposits appear to be greatly out of the course of the run of the ores on the northern shore of Meyer's Lake, I should explain that the strike of the latter, on going westward from the lake, changes from N. 60° E. to E. and W., this last strike bringing them to their posi-

Openings made by Messrs. Oliver & Manion.

tion on Silver Lake. But there are three or more separate beds of iron ore at Meyer's Lake, and it is not yet known to which of these the Silver Lake deposits correspond. The ore so far discovered is of much the same character as that at Meyer's or Christie's Lake. It is a compact, bluish-black magnetite, and contains about 64 per cent. of metallic iron, and but little titanic acid, as seen by the following analysis by Mr. Christian Hoffmann, made in the Laboratory of the Geological Survey, February, 1875:— Analyses.

Magnetic oxide of iron *	88·59
Titanic acid	1·75
Insoluble residue	5·75
Metallic iron	64·15

For the sake of comparison, I may give here an analysis made by Dr. Harrington of a specimen from the Meyer's Lake beds, as given in the Report of Progress for 1873–74, p. 210.

Magnetic oxide of iron *	90·61
Titanic acid	2·83
Phosphoric acid	0·05
Metallic iron	65·62

The foregoing analysis prove these ores to be of good quality, and as they are within a comparatively short distance from the Kingston and Pembroke Railway (ten or eleven miles), there is no doubt that if in quantity they will soon be extensively worked. I have already in a previous Report (Report of Progress 1872–73, p. 174), given all the information in my possession respecting the Meyer's Lake iron ores, and mentioned how they could be shipped *via* the Tay River and Bob's Lake to the line of railroad. Little further then remains to be said respecting the Silver Lake deposits, as the same remarks apply to both locations. The recent discoveries of ore, however, at the last named lake, certainly give additional encouragement to the mining enterprise in this section.

Localities of minor importance. In the list of iron ore deposits given on page 112, I have mentioned a few localities which have not been described in my previous reports; these are of minor importance, from the fact that the ore is either very impure or exists in but small quantity. They are useful, however, in indicating the course of the ferriferous belts, and we may here give them a passing notice:

Wolf Lake Deposit.—The only mention hitherto made respecting this

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* Calculated from the metallic iron.

Extract from a report by Mr. Murray.

deposit of iron ore, is in the report of the Geological Survey for the years 1852-53, p. 137, and as copies of this report are now somewhat rare, I shall quote what Mr. A. Murray has there said: "One of the localities visited was on the twenty-first lot of the ninth concession of Bedford, where the magnetic oxyd occurs at the foot of a ridge of gneiss, associated with a greenish rock, consisting of an aggregate of greenish feldspar, and numerous large prismatic crystals of greenish hornblende, in a pale fawn-colored calcareous base. The bed to which it belongs is not well exposed, as it lies in a hollow, the greater portion of which, at the time I was there, was covered with growing grain; but its presence was indicated in the same position and associated with the same minerals, by the fragments strewed upon the surface for about a quarter of a mile in a north-east direction from where it was first seen. To the westward there is a fault running N. 25° W. and S. 25° E., which throws the ridge of gneiss about 150 yards to the south-eastward on the south-westward side, but although a careful search was made for the continuation of the ore, both in the direction of the dislocation, and on the south-western continuation of the ridge, it was nowhere found. The bed of ore did not appear to be over three or four feet thick."

Examination with the dip-needle.

Horizon of th Wolf Lake or

Since the foregoing was written, I have several times examined this deposit in Bedford. Nothing further, however, has been done in the way of working it, although, from an examination made with the dip-needle, there is some reason to suppose that the ore exists in considerable quantity. The bed or beds of iron ore here are undoubtedly on the course of the ferriferous horizon upon which is situated the Hon. G. W. Allan's deposit in North Crosby, and form an outcrop upon the opposite side of the synclinal which exists between these deposits and the Fournier and Bygrove mines (see map). Other exposures of magnetic iron ore, near Wolf Lake, on the twenty-fourth or twenty-fifth lot of the tenth concession, are probably on the run of those on the twenty-first lot of the ninth concession of Bedford. The two localities are fully one mile and a quarter apart, and it is more than probable that further discoveries will be made in the intervening country.

Spectacle Lake Deposits.—Iron ore occurs in the vicinity of a small lake of this name, situated about a mile to the eastward of Wolf Lake, on the eighteenth and nineteenth lots of the eighth concession of North Crosby. The ore occurs in diorite, and appears to exist in considerable quantity, but contains many impurities. An attempt was made some years ago, by an American Company, to work the deposit; but after one shipment of ore, *via* Westport, on the Rideau, the enterprise was aban-

Impure ore.

doned. The position of the deposit, at a considerable altitude in what have been termed the "Westport Mountains," is against its future prospects.

ituation of Itchell's eposits.

Mitchell's Deposits.—I could learn little respecting these deposits. They occur somewhere in the rear of the township of North Crosby, in the vicinity of the twenty-seventh lot of the seventh concession, and to the westward of the Hon. G. W. Allan's property; but the country here is exceedingly rough, and nothing has been done in the way of testing them.

Iorizon of eposits on the outh shore of Ieyer's Lake.

Meyer's Lake Deposits (southern shore).—These beds are quite distinct from those already noted as occurring on the northern shore of the lake, being in a much higher horizon, although lower than the Fournier and Bygrove iron ores. They are by some regarded as the continuation of the last-named deposits; but this is not their true position. They occur between the road and the lake, on lots seventeen and eighteen of the second concession of South Sherbrooke, and are immediately beneath the highest or Farren's Lake band of limestone. The ore is of an excellent quality, resembling that of the Fournier and Bygrove mines, but does not appear to be in quantity. No openings of any extent have been made.

xtent of ordon's deposit ot known.

Gordon's Deposit.—This deposit of iron ore is near the town line between South Sherbrooke and Bathurst, in the sixth concession and on the twenty-seventh lot of the last-named township. It is probably on a continuation of the ferriferous belt from the Foley and McVeigh lots, as it is immediately overlaid by the Crow, Rock and Silver Lake band of limestone. (See Report of Progress, 1873-74, p. 104.) The extent of this deposit is not known, as it has not been at all developed, but fragments of the ore obtained appear to be of excellent quality.

nportant ores.

Having thus briefly noticed these five localities, of which nothing further can at present be stated, I pass on to give a few additional particulars respecting the more important ores which form the remainder of the list. These are the Howse, Allan, Bygrove, and Fournier deposits, all of which have been alluded to in former Reports of Progress.

Howse Iron Deposit.—This is one of a series of outcrops of iron ore, which occur at intervals, from the fourth lot of the first concession to the eighth and ninth lots of the fourth concession of Bedford. These have been known for a great number of years, and specimens of the ore were obtained by the surveyors, when laying out the township, upwards of sixty years ago. But excepting the little work done on the Howse lot (lot four, concession one), during the years 1869 and 1870 (see Report of Progress, 1870-71, p. 312), the deposits have, up to the present time, remained as they were originally found. The shipment of fifty tons of ore from the Howse deposit, in the year 1869, to Charlotte, N. Y., as far as I have been able to learn, was attended with satisfactory results, at least as regarded the quality of the ore; but the long carriage—seventeen miles—over sandy and very hilly country to Westport Village, on the Rideau, before it could be shipped to Kingston, proved a decided obstacle to the enterprise. The ores, at the surface, are not as pure as many of those in South Sherbrooke, and are more mixed with rock matter; still this is in a great measure compensated for by their nearness to the Kingston and Pembroke Railway. For it will be remembered that the very impure iron ores of the Chaffey mine, near Newborough, on the Rideau, have been mined for years successfully, merely in consequence of their being upon navigable waters, although the ore, besides containing 9·80 per cent. of titanic acid, only averages about 50 per cent. of metallic iron.

Shipment of ore in 1869.

Advantage of proximity to the Kingston and Pembroke Railway.

The Howse deposit is of an exceedingly irregular character, and it would be a difficult matter to draw any definite outline that might be said to represent the shape of the mass of ore. The greatest length, however, is on the strike of the bed, namely, nearly north-east and south-west, and at one place the breadth appeared to be from fifteen to twenty paces. Through this last distance, however, there are several *horses* of rock. Beyond these facts, I can state nothing respecting this deposit. That there is visible a great quantity of ore is undoubted, and as it can be mined in the cheapest manner, namely, by open cuttings, there seems no reason why it should not be profitably worked. The position of this and the adjoining beds of iron ore is almost immediately beneath the Wolf Lake, Crosby Lake and Pike Lake band of limestone, which is the south-eastern outcrop of the Bob's Lake, Tay River and Meyer's Lake band, on the opposite side of a synclinal form. (See Report of Progress, 1873-74, p. 104). Consequently, these ores are in the same stratigraphical position as those represented by the Meyer's Lake and Silver Lake deposits. This fact of the occurrence of outcrops of iron ore in the same stratigraphical position, on both sides of a synclinal form, is, I think, sufficient proof of the continuity of the ore, not only in length but also in depth. The occurrence of strongly rust-coloured gneisses in many parts of the Bedford basin or synclinal, between Bob's and Potspoon Lakes, convinced me that this terriferous horizon is brought, or almost brought, to the surface by undulations in several places between the two divergent outcrops of ore. It also seems to me highly improbable that the iron ore should have only

Character and extent.

Stratigraphical position.

Supposed continuity of the ore.

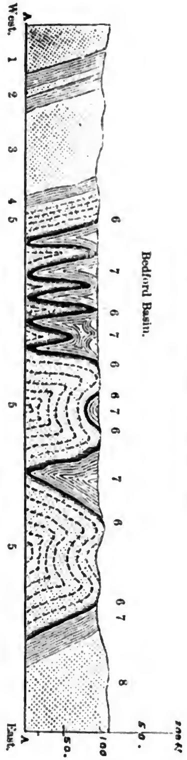
been deposited to the limited extent seen along the two outcrops of the same horizon of rock.

Section across Bedford.

The accompanying section across the township of Bedford will make these points clearer:

No 2.

GENERALIZED SECTION ACROSS BEDFORD.



Horizontal Scale, one mile and a half to an inch.

A. A. Level of Rideau Lake, 400 feet above the sea. 1. Lower gneiss. 2. Crystalline limestone, with a band of gneiss. 3. Second gneiss. 4. Second crystalline limestone. 5. Hornblendic gneiss and diorite, below iron horizon. 6. Outcrops of magnetic iron ore. 7. Third and upper crystalline limestone, with garnetiferous gneiss. 8. Gneiss.

Allan's Iron Ore Deposit.—This deposit of magnetite occurs on the twenty-seventh lot of the fourth concession of North Crosby. It is close to the town line of South Sherbrooke, and a little over half a mile south-eastward of the Fournier mine. Nothing whatever has been done here since the autumn of 1868, and the excavation then made by the Hon. G.

W. Allan is filled with water and *débris*. The question, therefore, as to the extent of the deposit, yet remains undecided; but as the surface indications are promising, and the ore of good quality, it is altogether probable that mining might be carried on with profit for some time. The route to the Kingston and Pembroke Railway is the same as that from the Meyer's and Silver Lake deposits, viz.: *via* the Tay River and Bob's Lake, and from the Allan deposit to the Tay River, the distance is about two miles. For the purpose of reference and comparison, I append a partial analysis of this ore, taken from the table of analyses, Report of Progress, 1873-74:—

Extent of the Allan deposit not known.

Analysis.

Magnetic oxide of iron	90·14 = metallic iron 65·27
Phosphorus	0·07
Titanic acid	1·03
Insoluble matter	5·25

The iron ore occurring on lot twenty-seven of the seventh concession of North Crosby undoubtedly belongs to this horizon, but the distance between the two outcrops is about two and three-quarter miles.

Bygrove and Fournier Deposits.—Both of these deposits of magnetite occur in the first concession of South Sherbrooke, and are in the same horizon. The Bygrove mine, on the third lot, has remained unworked since the year 1869, when it was to some extent worked by Mr. George Oliver, of Perth. The Fournier deposit on the fourteenth lot, however, has from time to time been more or less mined. During the summer of 1873, the last attempt at raising this ore for market was made. A shaft was sunk to the depth of one hundred and ten feet, and the Company raised in all about 600 tons of good ore. At this depth, however, the deposit became very irregular and uncertain, and as the ore could not be extracted without the removal of much rock, work was abandoned, and has not been resumed since. I may here mention a fact respecting this iron horizon that is not generally known—namely, that at a short distance from the Fournier mine, on the fourteenth lot, the ferriferous belt passes beneath Farren's Lake, in the second concession, its strike changing and coinciding with the course of the lake. On its exit from the lake, at its western end, the zone again becomes clearly marked by the presence of iron, until on the third lot of the first concession we arrive at the deposit of ore constituting the Bygrove mine. Specimens of ore from these two deposits gave about an equal percentage of metallic iron, the Fournier yielding to analysis 59·59 per cent., and the Bygrove 59·55 per cent. In the Report in which these analyses were first given, (Report of Pro-

Bygrove mine not worked since 1869.

Work at the Fournier mine in 1873.

Horizon of the Fournier and other deposits of iron ore.

gress, 1871–72, p. 123), I further stated that the Bygrove and Fournier ores were free from titanium, and that it appeared extremely probable that they would be found to belong to beds "somewhat higher in the series than the titaniferous ores." This supposition has since been clearly proved. They have been found to lie in the highest iron-bearing horizon, and immediately below the highest band of crystalline limestone. The second, or underlying belt, is that on which are situated the Meyer's and Silver Lake deposits, the ore from which, as we have seen, contains from 64 to 65 per cent. of metallic iron, and invariably a small percentage of titanic acid; whilst, in the next or third underlying belt, represented by the McVeigh, Foley and Eagle Lake deposits, the ore is more titaniferous, and is further characterized by its peculiar coarsely crystalline character, and by the presence of apatite or phosphate of lime.

Three horizons of iron ore.

I have thus, I think, with some degree of certainty, succeeded in establishing the existence of three distinct horizons of iron ore, each of which possesses some peculiar characteristics by which it may be again recognized. Should such prove to be the case, it will be a most important step gained, and an invaluable aid to future predictions respecting the iron ores of the Laurentian rocks.

IV.

THE GEOLOGICAL STRUCTURE OF THE REAR PORTION OF LANARK COUNTY.

In what I have here to state respecting the geology of Lanark County, I shall advisedly restrict my remarks to the kinds of rocks, and to their distribution through the country examined. For I am convinced, that in the present imperfect state of our knowledge respecting the Laurentian rocks proper, and those which immediately follow or interpose between them and the lower Silurian formation, any positive assertions as to the relative ages of a large portion of those examined last season would be hazardous.

Classification of rocks.

KINDS OF ROCKS.—The rocks are of similar characters to most of those previously examined and reported on. They may, however, for the sake of convenience in the present description, be grouped as follows:—

I.—*Mica-Schist Group*,—embracing mica-schists, calcareous schists, quartz slates, hornblende slates, imperfect gneisses or micaceous sandstones, and some sandy crystalline limestones.

II.—*Dolomite and Slate Group*,—embracing ferriferous dolomites, glossy mica-schists, diorite and chlorite-schists, grey magnesian limestones (cupriferous), some white crystalline limestones and crystalline diorites.

III.—*Diorite and Hornblende-Schist Group*,—embracing coarsely crystalline diorites, fine-grained gneissoid diorites, diorite slates and hornblendic or pyroxenic schists, serpentine limestones, and beds of magnetic pyrites.

IV.—*Crystalline Limestone and Hornblende Rock Group*, — embracing several varieties of crystalline limestone (*apparently without serpentine*), black, massive hornblende rock, hornblende-schist, and some diorites.

V.—*Gneiss and Crystalline Limestone Group*,—embracing micaceous and hornblendic gneisses, white crystalline limestones with serpentine and graphite, hornblende rock, some diorites and deposits of magnetite.

A sixth group previously described.

A sixth group, embracing coarse orthoclase gneisses, felsites, garnetiferous gneisses, pyroxenites, crystalline limestones and white quartzo-orthoclase rock, with large deposits of apatite, occupies the front portion of Lanark County, but this has been fully described in previous Reports.

The five foregoing groups of rocks occupy distinct and separate positions in the country, but at present it is not known whether they represent one or more formations. They occur in the relation just given, but in what stratigraphical order is uncertain. I can, however, distinguish amongst them, besides the Lower Laurentian of Sir W. E. Logan, rocks which, in some respects, resemble those of the White and Green Mountain series of New England, as described by Dr. Hunt, but lines of demarcation between these and the first mentioned are anything but clear. These points, however, will be again brought forward in the course of this Report.

Section.

Before proceeding to describe the detailed characters and distribution of the rocks in each group respectively, I would direct your attention to the accompanying section (see map), which shows the succession in which they were observed, on a line extending from the mica-schists in Levant township eastward through the townships of Dalhousie, Lanark and Ramsay. The spaces left at the lines of contact between the different groups of rocks, are intended to denote the uncertainty existing as to their relative positions.

Explanation of Section.—On the extreme west of this section, we have the mica-schist group I, dipping at an angle varying from 10° to 45°. Separated from this by an elevation of red gneiss (a) is the dolomite and slate group II, followed immediately by the diorite and hornblende-schist group III, with serpentine limestones. Next in apparent succession is a great undulating volume of white and banded crystalline limestone, with hornblende rock and schist IV, the whole covering a very large area, and finally becoming overlaid by the gneisses and crystalline limestones of V. In this last group magnetic iron ores occur at three distinct horizons.

I.—Mica-schist Group.

In the Report of Progress for 1872–73, pp. 157 and 158, I briefly alluded to this group, stating that the distribution of the rocks composing it was being worked out in the townships of Levant and Blythfield, and hoping that in a succeeding Report something definite might be said concerning them. But after a careful examination of both Palmerston and Levant, where they are most largely developed, I have been unable to do much more than to collect some further facts respecting their distribution in these townships, and to draw the lines which may be said to represent their eastern and western boundaries.

Characters of the mica-schist group.

The series is particularly characterized by an abundance of mica, which varies from large foliated plates of a silvery white colour to very small scales. The lowermost beds are grey quartz-schists with partings of brownish mica, and with a few interstratified beds of impure sandy limestone. Next in frequency are friable quartzose schists, and silvery-white foliated mica-schists with clusters of coarse garnets. Amongst these last are several interstratified bands of sandy, white, and easily disintegrating crystalline limestone.

The whole of these schists and limestones constitute a belt averaging about one and a half miles in breadth in the townships of Palmerston and Levant. Their strike is in a north-easterly and south-westerly direction, and their dip, which is steady to the eastward, varies from horizontal to an angle of 45°; this last dip occurring apparently towards the summit of the series, or on the eastern side of the belt. In most of the schists garnets are abundant; but, so far, I have been unable to recognize in them the minerals chiastolite and staurolite, so characteristic of the White Mountain series. Further, the attitude of these schists in the townships named is worthy of notice. Instead of the rounded ridges of rock and undulating character of the country so generally observable in the areas occupied by the Laurentian gneisses, we have in Palmerston, Levant and Blythfield, abrupt escarpments, ledges and steps of rock, much resembling the conditions observed on approaching limestones of Lower Silurian age. Towards the summit of the mica-schist group, but in what relation is unknown, there occurs a considerable thickness of a brownish, sandy, crystalline limestone, filled with white siliceous layers and patches. In this no stratification is observable; but its general course can in most cases be made out, with a little care, by means of the siliceous fragments. Having thus given the general appearance and characters of the rocks forming this group, I shall now proceed with some local details.

Distribution of the rocks of the mica-schist group.

The silvery white mica-schists are largely developed to the westward of Robinson's Lake, in Levant township, on the government road leading into Palmerston, and are here highly garnetiferous. The dip here seldom exceeds an angle of 45°, and is steady to the eastward. The outcrops of the strata form abrupt ledges or escarpments, down which the road winds, and some of which are fifty, eighty and even one hundred feet in height. The whole of the rocks are more or less rust-coloured on their weathered surfaces, but are more particularly so at or towards the base, and amongst the quartzose schists and slates. The strike in general is a very little east of north and west of south, and with this course they extend south-westward through Levant into Palmerston, and cross the road leading up from McLaren's Depot Shanty. Beyond this point they are lost sight of, and appear to be cut off or interrupted by the great red gneiss area of the Crotch Lakes and the Mississippi River. (See map.) To the north-eastward in Levant, we again come upon an extension of the same belt, on the eighteenth lot, in the fourth concession. Here, there is a great development of the brilliant, coarsely foliated mica-schist, but with only a few scattered garnets. The dip is at an angle of 45°, but varies in direction from south-east to north-east, caused probably by some local disturbance of the strata. The rock when freshly fractured has a glimmering or glistening appearance ; at the surface its colour is in general greyish-brown. On this lot it is apparently overlaid by a band of whitish-brown, sandy, crystalline limestone, everywhere characterized by interstratified layers and bunches of opaque, white chert, or quartz, and tremolite. This band, however, does not appear to be large. On the west half of lot twenty, in the fourth concession of Levant, the schists strike E. N. E. and W. S. W. The strata here are rust-coloured quartzose schists, and very coarse, whitish, calcareous schists come in, associated with some bands of white crystalline limestone. It is of importance to note here that the schist becomes charged with calcareous matter on approaching the bands of limestone on either side. North of this, on the twenty-first lot in the fourth concession, and apparently beneath the bands of limestone just noted, grey, speckled micaceous gneisses appear, striking E. N. E. to the north branch of the River Clyde. In the bed of this stream, on lot twenty-two, there occurs an outcrop of a greenish and pinkish crystalline limestone.

Round Lake.

Round Lake lies diagonally across the twenty-fourth lot of the fourth concession of Levant, its north-eastern and south-western ends, however, being respectively in a portion of lot twenty-five in the third, and lot twenty-three in the fifth concessions. The shores at the south-western end, and along the whole north-western side of the lake, are occupied by grey micaceous and very quartzose gneisses, striking to the north-eastward, and dipping at an angle of 60° to the south-eastward. On this strike the gneisses, followed by the coarse mica-schists, continue through to Clyde Lake, situated on the boundary line between Levant and Blythfield, on the second concession line of the last township. The strike, however, on approaching Clyde Lake, becomes more northerly, and even north-westerly, and there is every indication of a general change in the course of the whole belt. But this fact yet remains to be proved by future exploration in Blythfield. I may here mention that the section given by Sir W. E. Logan, in the Geology of Canada, 1863, p. 29, was made just five miles to the north-westward of Clyde Lake, namely, at the High Falls on the Madawaska, a tributary of the Ottawa. Sir William clearly states that here "the dip of the strata is pretty constant in direction," and is "from twenty-five to forty-five degrees east of north, varying from fifteen to thirteen degrees." This statement, taken in connection with what I have already said respecting the change in strike of the rocks at Clyde Lake, further supports the probability that the whole group of rocks under description, on leaving Levant run north-westward through Blythfield, and cross the Madawaska some distance to the west of and below the rocks composing the section at the High Falls. Further, respecting this turn in the course of the rocks, it is to be observed that as far to the north-eastward as Arnprior, at the mouth of the Madawaska, over twenty miles distant in a direct line from Clyde Lake, the same indications of a general turn are visible, and bands of limestone, which, as far as this place, have had a constant strike to the north-eastward and dip to the south-eastward, thence are trending north and north-westward, with dip to the east and north-eastward. But on this most important point I shall speak at greater length in a subsequent part of this Report.

Clyde Lake.

Important change in strike.

Rough country in Levant.

The whole country occupied by the mica-schist group in Levant is of an exceedingly rough character. The greater part of it is still thickly timbered, and roads are few and far between. Hence the working out of geological details was everywhere attended by much difficulty. Towards the south-western extremity of the belt, however, in the township of Palmerston, the country is better cleared, and the succession of the strata better seen. I shall, therefore, before dismissing this subject, give some further notes on the apparent sequence of the rocks on the road which runs north-westward through this township, from McLaren's Depot Shanty near the Mississippi River. On this road, and on the sixteenth lot of the ninth concession of Palmerston, we come upon the sandy, brownish and cherty limestone band, which marks the eastern boundary of the mica-schist group. This is undoubtedly a continuation of the the band seen to the westward of Robinson's and Joe's Lakes in Levant. With this limestone in Palmerston, from the lot just mentioned to lot number seventeen in the eighth concession, there is associated a very large amount of pure, white-weathering orthoclase and quartz rock. This occurs in great bedded masses, as well as in detached lenticular patches in the limestone. In intimate connection with both of these rocks are bands of speckled hornblende slate, rock, or schist, in which the hornblende occurs in distinct crystals of a greenish colour, in a matrix of a greyish-white or pure white granular feldspar, which I take to be oligoclase. The strike of these beds is to the N. E. or E. N. E., with south-eastward dip at an angle of 45°. Further along the road, at a point where Antoine's Creek crosses it, on lot eighteen of the eighth concession, the rock on either side is a similar speckled hornblende slate, strongly rust-colored, and with partings of small-scaled brownish mica. No limestone was observed here. A short distance beyond this again, on the right or east side of the road, is a high escarpment of sandy, brown-weathering mica-schist, dipping at a very slight angle to the eastward, and having some impure beds of limestone interstratified with it. Such strata continue for a considerable distance as an escarpment along the right of the road, while to the left, in a position beneath them, sandy crystalline limestone and white orthoclase rock again come in.

Succession of the strata in Palmerston.

On lot twenty-three of the eighth concession we have a similar rust-colored series, and much of the rock is a micaceous quartz schist. Here also there occurs a large area of a similarly coloured orthoclase and quartz rock, which would appear to bound or limit in this direction the more schistose division of this group. Immediately to the north-westward of this rust-coloured orthoclase rock, in portions of the twenty-fourth, twenty-fifth and twenty-sixth lots, in the seventh and eighth concessions of Palmerston, the fine-grained, greyish-white gneisses come in, in considerable thickness. They are here directly on the strike of those we have previously described as occurring at Round and Clyde Lakes in Levant, where they likewise form the western boundary of the mica-schists and quartz slates. In Palmerston, however, they are much more distinctly seen, and I was enabled to study them in greater detail. On lot twenty-five, and a part of twenty-six, in the eighth concession, these gneisses were the only rocks observed. Their weathered surface is of a light greyish or white colour, glistening in places from the presence of minutely divided mica. On fracture, they are seen to be composed chiefly of finely granular, translucent quartz, together with small scales of black mica, and a few garnets; grains of magnetite are also abundant; and the occurrence of this mineral first led me to institute a comparison between the micaceous gneisses of Palmerston, and certain schists occurring on the Addington Road, in the townships of Kaladar and Barrie, immediately above a great thickness of green slate and diorite belonging to Division B. of the Hastings Series. In Kaladar and Barrie townships the slate everywhere contains disseminated crystals of magnetite, and is closely associated with a sandy mica-schist, which often becomes a conglomerate. In this conglomerate the pebbles are flattened and lengthened out along the plains of bedding and give a peculiar jagged aspect to the weathered surface of the rock. In Palmerston, we find similar rough-surfaced zones running through the fine-grained gneisses or sandstones. These I, at first sight, thought were due to the weathering out of siliceous or tremolitic layers in the rock, but on closer examination I found that they consisted of detached lenticular fragments of quartz, distributed in clusters along certain planes of bedding. The matrix in which these fragments are embedded is further more micaceous than other portions of the rock, and in some specimens of this nature, subsequently compared by me with the schist enclosing decided pebbles on the Addington Road, I found that the former only differed from the latter in being firmer, and of finer texture. The matrix in both cases might correctly be called a micaceous sandstone, and it is not unreasonable to suppose that the same agency which has changed a loose friable schist into a firm, massive gneissoid rock, should also have considerably altered the condition of the enclosed pebbles. Looking, then, at the jagged-weathering schists in Palmerston in this light, I am strongly impressed with their resemblance to a portion of the schists on the Addington Road, and think it extremely probable that the conglomerate is here also represented in an altered form. This point, however, has such an important bearing upon the position and sequence of the whole group of rocks,

Comparison between gneisses of Palmerston and schists on the Addington Road.

that I hesitate to do more at present than hint at the probability. I may, however, state that should such prove to be the case, it will place the whole mica-schist group in a position towards the summit of the diorite rock and green slate series of Division B, (Report of Progress, 1866-69, p. 149) and beneath the grey calc-schists and impure limestones of Division C. of the Hastings series.

Beyond these gneisses or micaceous sandstones in Palmerston, the measures could not be clearly made out. They, however, appear to consist of a repetition of strata similar to what have been already described, namely, sandy-weathering limestones, white quartzo-orthoclase rock, mica-schists, and micaceous quartzites. These extend throughout the whole country in Palmerston westward to Trout Lake. The general strike of the rocks is to the north-eastward, but the dip is at a much steeper angle than that heretofore described.

Trout Lake.

South Canonto and Miller.

To the westward of Trout Lake in South Canonto and Miller townships, a great gneiss area comes in, and forms the boundary of the schists in this direction. The lowest zone of rock observed before coming to this gneiss area, consists of dark greenish hornblende-schist, with layers and patches of yellowish-green epidote; but the relative position of this with regard to the mica-schist group has not been clearly made out.* On the continuation of the mica-schist group to the south westward, through Clarendon and Barrie, the mica-schists cease to be a characteristic feature, but the associated sandy limestones become extensively developed. This fact I have already alluded to in describing the rocks occupying the Clarendon basin in the Report of Progress 1872-73, p. 157 *et seq.*

Clarendon and Barrie.

Extent of Group I.

In conclusion, I may state that, though varying much in different localities, the mica-schist group (I.) may be recognized and traced from its position in Levant and Palmerston south-westward through Clarendon, Barrie and Kaladar, and thence westward through the southern portion of Elzevir to Bridgewater village, and Madoc township, in which latter localities it is largely, in fact almost wholly, represented by the schistose conglomerates mentioned in my former Reports. The whole distance is upwards of sixty miles.

Red gneiss area.

[*Red Gneiss Area or Belt* (A.)—This belt of rock, as shown by the section (see map), separates the mica-schist group (I.) from the dolomite and slate group (II.) It appears to overlie the former, and invariably shows the same constant dip to the south-east and east. But extended observations on its course for a number of miles, seem rather to show that its present position is due to an uplift or overturned elevation of an older gneiss series. This gneiss forms a ridge or mountainous belt of country (shown on the map) all the way from the Mississippi River, in Palmerston, to and beyond Joe's Lake, a lake situated on portions of lots thirteen, fourteen, fifteen and sixteen, in the fourth concession of Levant. The rock is a fine-grained granitic gneiss, composed largely of flesh-coloured feldspar and greyish quartz, and differing in no respect from most of the gneisses heretofore described as Lower Laurentian. At Joe's Lake, the country which it occupies is particularly hilly, almost as much so indeed as to form a serious obstacle to waggon travel on a road which has been constructed across it. Northward of the lake, however, this hilly tract becomes depressed, and as the rock was not observed in the adjacent township of Darling, it must either disappear beneath overlying rocks, or, conforming to the N. W. bend just described as occurring in the mica-schist group, run diagonally or north-westward with this group across the township of Blythfield. The only other fact worth mentioning respecting this gneiss belt, is the occurrence of red hematite, in places along its eastern margin, and immediately beneath the ferriferous dolomites of the the next group in succession. This ore, however, has never yet been found in anything like economic quantity. It occurs in layers and threads in a zone of felspathic rock, which appears to have been at one time broken up and re-cemented. The only localities in which I know of its occurrence are at Robinson's Lake, and near a small sheet of water known as Caldwell's Lake, situated on lot number one in the eleventh and twelfth concessions of Levant.]

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* For a further description of the association of rocks in Miller, Clarendon and Barrie townships, see Report of Progress 1872-73, p. 142 *et seq.*

Joe's Lake.

Red hematite.

II.—Dolomite and Slate Group.

Immediately following and resting upon the gneiss just described are the ferriferous dolomites of the dolomite and slate group. The rocks of this group, I may mention at the outset, are unlike any so far met with in the Lower Laurentian series. They correspond more in their general characters with those constituting Division B of my Report on Hastings County, and resemble in many points portions of the Huronian of Sir W. E. Logan, and of the rocks of the Eastern Townships. Being aware, however, how little importance is to be attached to mere lithological resemblances as determining in any way the age of a group of rocks, I do not mean to convey in this statement anything more than the fact that

Resemblance to rocks in other parts of the county.

General characters of Group II.

such a resemblance does exist. The rocks comprising this group are largely dolomites, slates, and grey magnesian limestones, all of which are more or less cupriferous. Subordinate to these are beds of diorite and chlorite schist, black chert or hornstone, and white crystalline limestone. The limestone is clearly interstratified with the slates in thin bands, and likewise occurs above them in considerable thickness. The following section, however, will show the succession and relative position of the strata:—

Sequence of Rocks in the Dolomite and Slate Group, Levant.

		ESTIMATED THICKNESS.	
1.	Brown and rust-colored dolomites, traversed by veins of quartz carrying sulphurets and carbonates of copper	100 to 200	feet.
2.	Fine-grained, glossy-black, iron-stained slates, with nacreous lustre; cleavage with bedding.	90	"
3.	Buff-weathering, greyish-white, crystalline limestone, evenly and thinly bedded	135	"
4.	Slates similar to No. 2	8	"
5.	Crystalline limestone like 3	10	"
6.	Slates like No. 2, graduating towards the summit into a diorite slate and schist	35	"
7.	Slates like the last, but with rust-colored siliceous beds	60	"
8.	Buff-weathering slaty limestone, with interstratified layers of brownish dolomite	30	"
9.	Slates similar to the above, with thin beds of black chert	60	"
10.	Bluish-grey, buff-weathering, and finely micaceous limestones, much contorted and traversed by a net-work of small veins of dolomite and quartz. Beds of pure dolomite are also interstratified. These bear a striking resemblance to the calc-schists of Madoc, Tudor and Belmont. They are cupriferous...	100 to 300	"
11.	Bands of diorite and white banded crystalline limestones	doubtful.	
12.	Appearance of a break in the measures; rocks concealed by swamps	——	
13.	Large area of crystalline diorite (group III)....	——	

Strike and dip.

Throughout the foregoing section the strike of the rocks is almost north and south, or a very few degrees to the east of north, and west of south; the dip is constant to the eastward, and at angles averaging 45°. With this strike and dip, they extend from the neighborhood of the Mississippi,

Breadth of the belt in Levant.

Local details.

on the tenth and eleventh lots of the tenth concession of Palmerston, northward, through North Sherbrooke and Levant, to the twenty-second, twenty-third, and twenty-fourth lots of the third concession of Darling. The breadth of the whole belt through Levant is about one mile, but on reaching the last named township, it appears to have a greater spread. The most frequently recurring rocks, are the brown weathering dolomites, slates and diorites, and these are more or less cupriferous throughout their whole range. I shall now proceed to give some local details respecting their characters and distribution.

Palmerston.

Pure white dolomite.

North Sherbrooke.

Diorite.

In Palmerston, immediately to the south of the gneiss belt (A), and consequently in the same relative position as the rocks in Levant, of which a section has just been given, this group is represented by dolomites, brown-weathering ferruginous and glossy slates, white and greyish crystalline limestone, and some speckled diorites. The whole of these, however, are here very irregularly distributed, and as the country is exceedingly broken and thickly wooded, little could be ascertained with certainty respecting their sequence. One fact observed, however, is worthy of note, namely, that in this locality, much of the dolomite is of a pure white colour, and of so compact a texture, that it would be valuable for ornamental and decorative purposes, if sufficiently large blocks could be obtained.* Through North Sherbrooke to Robinson's Lake, in Levant, the relative positions of the rocks remain the same as given in the foregoing section, and crystalline diorite invariably forms their eastern boundary or limit. This last rock is well seen around the bridge over the Mississippi, on the sixteenth lot of the third concession of North Sherbrooke. It consists of a pretty uniform, granular mixture of a greyish or blackish-green hornblende and white-weathering, greyish feldspar. In places, however, its structure is granitoid, giving rise to a coarsely and irregularly blotched diorite, of very striking appearance. Through North Sherbrooke, and a portion of Levant, before coming to Robinson's Lake, the condition of the country is such that no close investigation was possible, but the general course

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* The following note concerning a specimen of dolomite from Dalhousie is by Mr. Christian Hoffmann :—

The specimen is finely crystalline, white where freshly fractured, but pale brown upon weathered surfaces. Through it are disseminated minute crystals of tremolite, occasional grains of quartz, and grains and layers of a greenish-grey translucent mineral, with a hardness of about 3, which proves to be pyrallolite. The material for analysis was separated as carefully as possible from the accompanying minerals, and after drying at 100° c. gave :—

Carbonate of lime	55·36
" magnesia	42·63
" iron	00·75
Insoluble	1·28
	100·02

of the belt is marked by frequent moss-covered ridges of the dolomite and slate. On Mr. Browning's and Mr. Gallagher's lots, six, seven and eight, in the seventh concession of Levant, however, a splendid opportunity is given for observing the succession of the rocks of this group. They commence on the western part of lots eight and seven, with extensive developments of the ferruginous dolomites, and black glossy slates, both of which are more or less copper-bearing. Between these and the red gneiss belt (A), the land is depressed and occupied by lengthened swamps, so that it is impossible to determine the character of the rock that immediately adjoins the gneiss. The greatest development of the slate is met with on going eastward from the dolomites, and in this direction also, the slate becomes of a greenish colour and graduates imperceptibly into a dioritic and chloritic schist. Towards the eastern or upper portion, buff-coloured, crystalline limestones come in, first in beds of only a few feet, and then in much greater thickness. These I examined very minutely for fossils, but without success. Serpentine was not observed, but I cannot state positively that it is entirely wanting. Still ascending, and towards the eastern portion of lot seven in the same concession, and through the centre of lot six, we have an extensive development of the bluish-grey, buff-weathering and finely micaceous limestones (10 of section). These are undoubtedly a part of the dolomite and slate series, and are likewise, frequently cupriferous. I mention this fact here, because it has an important bearing upon the position and age of the whole group. The underlying dolomites and slates, though possessing many characters in common with the rocks constituting Division B. of the Hastings series, yet have sufficient points of difference to make it possible that they may belong to a distinct and altogether different series. But in the case of the grey limestones last mentioned, their resemblance is so perfect, in every particular, to the grey magnesian limestones of Madoc and Belmont, which in these places overlie the diorites and green slates of B., (Hastings series) that I have no hesitation now in including them in this series. Consequently, this series in Levant, and that observed in Madoc and Belmont, Hastings County, may be considered as contemporaneous. In another part of this Report, the deposits of copper occurring in these rocks in Levant will be referred to; but I may mention here, that besides copper they also contain gold, as is also the case in the Madoc and Belmont series. On the lots last mentioned in Levant, namely, lots six and seven of the seventh concession, the grey limestones are everywhere associated with greenstones or diorites, which may either be true beds or injected masses.

Succession of rocks well seen.

Cupriferous rocks.

Resemblance to the rocks of division B. of the Hastings series.

Gold.

Diorites.

These become more frequent and important as we approach the great diorite area, which constitute our next mentioned group. The whole of the limestones have evidently been greatly disturbed. They are minutely corrugated, and are intersected in all directions by a net-work of siliceous and dolomitic veinlets, which weather in relief on the surfaces of the rock and give it a very striking appearance. The disturbances have almost entirely obliterated the planes of bedding, but the planes of jointing, which are at right angles to the former, are clearly seen.

Limestones greatly disturbed.

On lot twelve of the fourth concession, we again come upon the northward extension of group II. Here the grey limestones and dolomites are well seen, but the slates, probably on account of their occurring in depressions, are not represented at the surface. The whole country to the south-eastward of this lot, namely, through lots eleven, ten, nine and eight of the fourth and fifth concessions, is occupied by heavy, massive, dioritic rocks of greyish, mottled, or dark green colours. It is to be particularly noted here, that the coarsely blotched varieties of diorite are rarely met with in Levant. At the foot of Joe's Lake, in the western part of lot thirteen, in the third concession of Levant, we again have the ferruginous dolomites associated with slates and chloritic schists, and traces of copper were everywhere met with here. Further northward on lots sixteen and seventeen of the second concession of Levant, the mica schists are largely represented, striking a few degrees to the east of north with eastward dip at an angle of 45°. The surrounding country here is so thickly wooded that the other members of the series were not seen. Across the eighteenth lot in the first and last concession of Levant, a large band of a rusty-weathering dolomite runs north-eastward in a high ridge, varying in width from fifty to one hundred yards. Here, the diorites again form the eastern boundary, the country occupied by them being of a very rough and hilly character. Still to the northward of this lot, these rocks run into the township of Darling, and are seen from the eighteenth lot of the first concession, to the twenty-third and twenty-fourth lots of the third concession. On the first mentioned lot, on the land of a Mr. Elliott, the dolomite is again cupriferous, but none of the veins seem to be of any importance. The diorites associated with the dolomites in this locality present rather a streaked than a speckled appearance, owing to a different arrangement of the feldspar and hornblende, and a large portion of the rock is composed wholly of a greyish feldspar. In the third concession of Darling, on lots twenty-three and twenty-four, the dolomites still continue in considerable thickness. They cross the Calabogie Lake road, and pro-

Northward extension of Group II.

Copper.

High ridge of dolomite.

Cupriferous dolomite.

Calabogie Lake road.

bably extend eastward to the western extremity of White Lake, but bush fires in this direction prevented me from collecting any further details respecting their distribution. I have already stated that the average breadth of this belt of rocks in Levant, is about one mile. In Darling, however, I find it difficult to draw any lines which may be said to represent either its eastern or western boundary, as the rocks seem to be distributed in a very irregular and confused manner over a large part of the township. Further exploration in this section, however, is needed, and until such is completed, little more can be said respecting the continuation of the rocks northward.

White Lake.

Breadth of belt.

In conclusion, respecting the dolomite and slate group (II)., I may state, that in its course from Palmerston township to Darling, its uniformly straight northward bearing is remarkable. Its western outline is always well defined, while, on the other hand, its eastern one, bordering on the diorites, is somewhat irregular. Its southward course from Palmerston would bring it into contact with the great gneiss area, which occupies the southern portion of this township and much of Oso (see map), but the contact was nowhere observed. There is little doubt existing in my own mind, that the green slates and dolomites, which stretch from the south-western corner of Barrie township southward along the Addington Road, in Kaladar, are representatives of this group to the south; but by what windings, or in what way a connection is made between them, it is impossible to determine.

Supposed representatives of Group II. in Kaladar.

III.—DIORITE AND HORNBLENDE-SCHIST GROUP.

The term diorite is generally understood to apply to a rock consisting of hornblende and oligoclase, or albite, with little or no quartz. As might be supposed, however, there are almost infinite varities, due to variations in crystalline texture, and in the relative proportions of the constituents; and many varieties are found in the regions under consideration. Though it can hardly be said that the diorites in this group graduate into rocks in which pyroxene is the chief constituent, yet there is no doubt that pyroxene frequently replaces the hornblende in them, but in such a manner as to make it impossible to define the limits of each rock, or even to distinguish them without constant critical examination. The pyroxenic rocks constitute, however, a very small portion of the group, which as shown on the accompanying map, occupies a large area in portions of North Sherbrooke, Dalhousie, Levant, Lanark, and Darling townships. It may be separated into three sub-divisions or belts, as follows:—

Characters of diorite.

Subdivisions of Group III.

(1). Uniformly granular and speckled diorites.
(2). Coarse granitoid syenites and diorites.
(3). Slaty and schistose diorites.

Distribution of the three members of Group III.

The first belt constitues the extreme western portion of the group, and averages perhaps one-third of the whole. It extends from the northern end of North Sherbrooke, through the north-western corner of Dalhousie, and south-eastern portion of Levant, into Darling township. The second belt forms the centre of the group, and forms a range of hills, stretching from a point a short distance to the southward of the Mississippi River, in North Sherbrooke, through Bathurst, in the vicinity of the cluster of small lakes on the River Clyde, in the eighth and ninth concessions, and into the south-east corner of Levant. The third belt constitutes the remainder or eastern portion of the group, and occupies a large part of the centre of Dalhousie and the north-west and south-west corners of Lanark and Darling. The whole group extends into the last named township, and covers a very large area, which has not yet been examined.

Belt No. 1.

(1).—*Uniformly granular and speckled Diorites.*—The first or extreme western belt has been partially described in connection with the dolomite and slate group (II.), with which it is intimately connected. It embraces at least three varieties of diorite, all of which graduate into one another without any apparent regularity. The first, and perhaps the most commonly recurring variety, is a uniform mixture of a dark coloured, granular hornblende, and greyish, white-weathering feldspar (oligoclase?). This combination produces the mottled or speckled-weathering diorite, to which I have several times alluded, in the preceding pages, as immediately following the dolomite and slate rocks in North Sherbrooke and Levant. Quartz occurs in it more frequently than in either of the two varieties yet to be described. Iron pyrites in irregular grains, is nearly always sparingly present, and mica is almost entirely wanting. The second variety differs from the first, chiefly in being more coarsely crystalline. The feldspar predominates and gives a greyish-white colour to the weathered surfaces of the rock, on which the crystalline hornblende is very conspicuous. Iron pyrites and some mica is nearly always present. This rock occupies a very large portion of the western third of the diorite area (see map) in Dalhousie and Levant, and more especially in the vicinity of the cluster of small lakes before alluded to, which are formed by the Clyde River, in the eighth and ninth concessions of Bathurst. It graduates imperceptibly into the third variety of this sub-division, namely, that in which the horn-

Three varieties of diorite.

blende almost entirely supplants the feldspar. The weathered surfaces are invariably some shade of dark grey or greenish-grey. No distinct position can be assigned to it along the western belt of diorite rocks, as it occurs almost everywhere in connection with that last described, though most frequently through the south-eastern quarter of Levant, and through a large portion of Darling. Iron pyrites in it is abundant in finely disseminated grains, and on decomposition often gives a strong rust colour to the mass. Quartz is also generally present in fine grains.

Forms resembling *Eozoon.*

(2).—*Coarse granitoid Syenites and Diorites.*—The central portion of the Diorite area is occupied by the coarse granitoid and syenitic varieties. These are of special interest, as some of them seem to shew gradations from a true diorite to a coarse hornblendic granite or syenite, and closely associated with them occurs the first appearance of serpentine limestone with weathered forms resembling *Eozoon*. The relation of these syenites, and syenitic diorites, to the rocks that immediately precede and follow them is at present uncertain. Till quite recently, I regarded them as exotic masses, or exposures of the inferior red gneiss series, possibly along the crown of an anticlinal in the Diorite group. But subsequent and more extended exploration, and the further examination of a great number of rock specimens seems rather to shew that the diorites themselves pass by almost imperceptible gradations into these coarse syenitic varieties. The first change in this direction is marked by the occurrence, in the ordinary diorite, of a flesh coloured or red feldspar, scattered irregularly through the mass of the rock, in intimate association with the white-weathering feldspar (oligoclase), but apparently not a triclinic feldspar. In this variety of diorite, a light yellowish-green epidote is also observed, and it continues to characterize the rock in all its stages. The association of two distinct species of feldspar in the same rock is not uncommon. Von Cotta says, "many syenites contain oligoclase, as well as orthoclase or microcline, opening up a transition into diorite, which latter is essentially nothing but a syenite containing oligoclase instead of orthoclase. This trifling difference, which is usually connected with a coarser texture of the rock, may possibly only be a consequence of the different level at which it attained the solid state." And further, in this connection, Mr. Macfarlane in his Report on the Geology of Lake Superior (Report of Progress 1866, page 119), makes mention of a granite which "is coarsely granular, and consists of reddish orthoclase, a small quantity of a triclinic feldspar, dark-green mica and grey quartz." As this reddish feldspar

Transition of diorite to syenite.

increases in amount, the triclinic feldspar diminishes, and the rock assumes more and more the appearance of a Laurentian syenite. Notwithstanding, a triclinic feldspar is seldom entirely wanting, and is often observed to give its peculiar white, or greyish-white weathering character to portions of the rock. I have already mentioned, that epidote is present in the syenite, and both it and carbonate of lime were frequently observed coating portions of the rock. A short distance to the south-eastward of the Mississippi River, in North Sherbrooke, a coarse red syenitic rock, with epidote and small quantities of graphite, crosses the third concession line, and extends northward across the river into Dalhousie, whence it continues to a position to the north-west of the Poland Post Office, situated on the twenty-third or twenty-fourth lot of the fourth concession. Between this lot and the town line of Levant, syenitic rocks are largely developed, and present endless diversities of character. south-westward from North Sherbrooke, they were followed across Oso township into Olden, where they are again extensively developed along the line between these townships on lots nineteen, twenty and twenty-one of the first and eleventh concessions of both townships.

Serpentine limestone.

I have already mentioned the occurrence of serpentine limestone, in connection with these coarse syenites and diorites. It occurs in an irregular and disconnected manner along their eastern flank, close to where the more slaty and schistose sub-division of the diorite group commences. The limestone is, for the most part, rather coarsely crystalline, and is of a brilliant white colour; but there are also portions of a slaty character, and in these the serpentine occurs in layers marking the bedding. Other parts of the same band are of a finely granular character, weather brown or blackish, and are probably dolomitic. I would draw attention to the fact that the serpentine in this band is seldom in a disseminated granular form; and in this respect the band differs from others yet to be described, which occur in a higher portion of the series, and which closely resemble the serpentine limestones of Grenville and its augmentation. It also somewhat resembles a limestone brought from Cote St. Pierre, Petite Nation Seigniory, which is likewise associated with coarsely crystalline and blotched diorites. It was only observed in two or three localities, apparently in the same stratigraphical horizon. On the twenty-third and twenty-fourth lots of the third concession of Dalhousie, the serpentine occurs interlaminated with a finely granular and brown-weathering crystalline limestone, which exhibits on its weathered surfaces, forms very much resembling *Eozoon*. Some of the most promising fragments

Eozoon.

were sliced by Mr. Weston for microscopic examination; but Principal Dawson, to whom they were submitted, could only detect some very obscure forms, which he thought might be *Eozoon*. A similar limestone with serpentine was noted, crossing the twenty-sixth and twenty-seventh lots, on the line between the first and second concessions of Dalhousie; but in this no *Eozoon* structure was observed. I, however, picked up a loose fragment of limestone on one of the last mentioned lots, which, after being digested in a weak bath of acid, displayed this structure in a very marked manner. In Darling township, this band has not been found in place, but numerous large fragments of limestone containing a light yellowish-green serpentine, were observed in connection with some of the diorites.

Area occupied by sub-division 3 of Group III.

(3).—*Slaty and schistose Diorites.*—The third sub-division of Group III. occupies the whole eastern side of the area through Dalhousie, Lanark, and Darling, immediately bordering upon the limestones of Group IV. In it, the rocks are for the greater part slaty or schistose, but are occasionally massive. Their prevailing colour on weathering is a brownish-green, but on fracture they are black, greyish, or dark green. They are all traversed by joints at right angles to the strike of the strata, and in parts of the mass, the joints occur so close together, that the rock may almost be said to have a slaty cleavage. One variety of these schistose diorites is worthy of special notice. It consists of a friable or easily disintegrating blackish-green schist, containing an admixture of feldspar and carbonate of lime. The feldspar occurs in crystals or grains of a red colour, arranged in clusters or aggregations through the mass; and on the weathered surfaces, these present a great variety of forms. The slaty portions of the rock may correctly be called diorite slate. This is very fine-grained, and graduates into a massive rock, with transverse jointing. Associated with the slaty portions, and towards the extreme eastern border of the diorite area, deposits of magnetic pyrites occur in one or two places in Dalhousie. The distribution of these rocks (2) is shown on the map accompanying this report. It has, however, been mentioned that they constitute the eastern portion of the area occupied by the diorites of Group III, and that on their south-eastward course from Dalhousie, they either thin out, or are overlaid by the limestones of Group IV.; as through Oso, and a part of Olden, these limestones are seen in immediate contact with the coarse granitoid diorites and syenites, which, in Dalhousie, occupy the centre of the diorite area. The absence here of the schistose and slaty subdivision (3) of the diorite group, which should come in between the

Rock characters

Magnetic pyrites.

Absence of sub-division 3.

limestones and the syenitic diorites, is remarkable; and as it seems improbable that in so short a distance as that from Dalhousie to this portion of Oso these rocks should entirely thin out, there must be either a fault or an uncomformity between Groups III. and IV.

IV.—Limestone and Hornblende Rock Group.

Sharbot Lake, Playfairville and Lanark limestones.

Immediately following these diorites, and at the base interstratified with them, is a great volume of crystalline limestone and hornblende rocks. This is simply the north-eastward extension of the White Lake and Bolton Creek, and Upper Sharbot, Playfairville and Lanark bands of limestone which are mentioned in my last report (Report of Progress, 1873-74, page 104). These bands formerly considered as distinct, have since been proved to represent merely separate portions of one outcrop; consequently they will henceforth be described together, as the Sharbot Lake, Playfairville and Lanark limestone band. Considering the importance of this limestone, and that it differs both in general character and in appearance, as well as in many minor details, from any of the bands yet met with, I have placed it, with its associated rocks, in a distinct group. The area it occupies is number four on the map accompanying this report. It will at once be noticed that its distribution presents more the appearance of a great undulating sheet, than that of the single outcrop or upturned edge of a band. If the former, then, it must be referred to a more recent and unconformable system of rocks than that upon which it rests, but if the latter, it must represent an outcrop that is extended in undulations beyond the limits of its true horizon. The greatest width occupied by this group is from seven to eight miles in Dalhousie and Lanark, and, with one exception, the limestones are seen throughout; this exception is a comparatively narrow strip occupied by a belt of hornblende slate rock. This great breadth of limestone, however, is seen to lessen rapidly both to the north-eastward in Ramsay and to the south-westward in South Sherbrooke and Oso townships; and this fact, I think, renders the basin or shallow trough form of the deposits more probable. It may appear strange that this basin form should not have been at once observed by the successive dips of the strata on approaching the eastern and western limits of the area; but when it is stated that the strata are as often inverted or overturned as otherwise, and that it is only towards the central portion of the area that opposite dips denoting undulations occur, the difficulty of arriving at any positive conclusions respecting the true position of the rocks will at once be

General characters of Group IV.

recognized. Leaving this, then, as yet an open question, I shall proceed to give the general characters of the rocks constituting the group. They are as follows, in what appears to be the ascending order:—

Banded limestone.

1. Highly crystalline, striped or banded limestone, thinly and evenly bedded, showing alternate white and bluish-grey colours, and varying in texture from coarsely crystalline to very fine grained.* Much of this limestone might be correctly termed flaggy. In it the stratification is everywhere most distinctly marked by the light and greyish bands, and in this respect, as well as in the very few minerals it contains, it differs from the limestones which constitute a part of the succeeding gneiss and limestone group. The only minerals observed were tremolite, iron pyrites, and graphite, the last being always finely disseminated through the rock. Towards its junction with the diorite rocks last described, there are several thick bands of a blotched crystalline diorite, apparently interstratified with it, but whether these are truly interstratified masses, or merely outcrops or protrusions of the underlying diorites, is uncertain. Towards the summit the limestone is less crystalline, and assumes a uniform greyish colour, when it much resembles portions of the grey calc-shists of the Hastings series.

Dolomite abounding in tremolite.

2. Brown-weathering, crystalline, magnesian limestone, abounding in tremolite.† On fresh fracture the rock varies from a pure white to a flesh-red colour, and is of a rather coarsely granular texture. The tremolite occurs in interstratified layers or beds, which weather out in strong relief, and give the whole mass a very rugged appearance. This rock is very similar to some seen along the north shore of Hog Lake,

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* Mr. Hoffmann has examined both the bluish-grey and white layers of a specimen of this limestone, from the twenty-first lot of the tenth range of Lanark. The former contained finely disseminated graphite, (the cause of their colour) and likewise a considerable quantity of tremolite in crystals, some of which were more than half an inch in length. The white layers, however, were free from graphite, but contained a little tremolite in microscopic crystals. Minute grains of glassy quartz were also found in both the grey and white layers. The material for the following analyses was freed as carefully as possible from impurities, and dried at 100° C:

	Grey Layer.	White Layer.
Carbonate of lime	77·39	90·38
" magnesia	20·57	8·32
" iron	·78	·51
Graphite	·16	....
Insoluble	1·26	·90
	100·16	100·11

† A specimen of this dolomite, from the twenty-second lot of the eighth range of Lanark, has been analysed by Mr. Hoffmann. It was separated as far as possible from tremolite, and after drying at 100° C gave:

Carbonate of lime	52·12
" " magnesia	42·10
" " iron	·80
Insoluble	5·78
	100·80

south of Madoc, and to others in Clarendon and Palmerston townships. In Lanark County it is confined to one particular horizon, and appears to occupy a position immediately at the summit of the banded or striped limestones.

Hornblendic rocks.

(3.) Black hornblende rock, slate and schist, of the following distinct varieties:

a. Massive, black and finely white-speckled hornblendic rock, containing greyish-white feldspar in a minutely divided state. The whole rock is finely granular, and much resembles a trap.

b. Black and greenish hornblende slate and schist, with partings of brownish mica, and sometimes holding garnets in abundance.

c. Coarse and finely crystalline masses of green and greyish-green hornblende rock, containing small quantities of whitish feldspar, pink or white calcite, iron pyrites and quartz. This rock, by the addition of a greater amount of white feldspar, passes into a coarse diorite.

d. Fibrous or columnar hornblende rock, of a greyish-black colour and finely speckled character. This splits into long splintery fragments.

These four varieties of hornblende rock form a belt of considerable thickness immediately above the rugged weathering magnesian limestones (2) last described, through the whole of Lanark County, and have interstratified with them a few subordinate bands of white crystalline limestone. A greyish-white feldspar is generally present in a finely divided state, and this gives a whitish, speckled appearance, to the weathered rock. This feldspar is probably either albite or oligoclase, but it occurs in such minute grains that it is almost impossible to separate a sufficient quantity of it for analysis. In the fibrous varieties, the crystals of hornblende lie roughly parallel to one another, and there is a larger admixture of white feldspar. I was struck with the resemblance of this last variety of hornblende rock to the fibrous diorites of Elzevir and Madoc, which form a part of division B. of my Report on Hastings County, (Report of Progress 1866–69, page 149) the only difference between the two being in the colour of the hornblende, which in the latter localities is greenish, instead of grey or black.

Banded limestones similar to No. 1.

(4.) Striped and banded crystalline limestones, similar in character to those forming the apparent base of (1.) They have interstratified with them rust-coloured hornblende schists, which constitute fahlbands,* and a few beds of a feldspathic character. This zone of limestone may be a repetition of (1), but occupies a separate and distinct area.

Sub-divisions of Group IV. considered in detail.

The sub-divisions 1, 2, 3, 4 of Group IV., will now be considered in greater detail.

Characters of the banded limestones

(1.) *Striped or Banded Limestones*—These are the lowest rocks of the group. They immediately succeed the schistose sub-division of the Diorite Group III., at a great number of points both in Dalhousie and Lanark, and are also interstratified towards their base with masses of a blotched and speckled diorite, similar in character to much of that found in the underlying group. The banded structure already alluded to is generally very uniform and regular, but in places where the limestone is affected by local disturbance, it is corrugated or wavy. The rock splits readily in the direction of these bands, and affords flag-stones of large size. Towards its upper portion the stratification is not so evident, and the limestone is more uniformly white and crystalline. In its distribution it is affected by so many undulations that it is difficult to select a portion which will, with any degree of accuracy, represent its approximate thickness. But from close measurements taken at several points, where the band suddenly assumes a vertical attitude and greatly narrows in surface width, I cannot estimate its thickness at less than from 5,600 to 6,000 feet. This thickness, however, would of course be considerably reduced should any sharp folds repeating the strata be hereafter detected in this locality. The position where these measurements were made is close to the line between the townships of Lanark and Ramsay, in the second concession of the first-named township, and from lots twenty-two to twenty-five inclusive. This portion of country, as may be seen by reference to the map, lies between Indian Creek, a tributary of Taylor's Lake, on the north-westward, and another small creek, also a tributary of the same lake, but un-named, to the south-eastward. Indian Creek forms a natural dividing line between the limestones and a series of underlying gneisses, schists and slates, while the smaller creek to the south-eastward likewise separates the former from the overlying, brown-weathering tremolitic limestone (2). Across the whole of this area the strata are vertical, but remain so only for a limited distance in the direction of their strike, which is here very nearly east and west. From

Flag-stones

Thickness of limestone.

Vertical strata.

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* In Norway, according to Macfarlane, gneiss, mica-sch'st, hornblende-schist, etc., are also found constituting fahlbanus.

this position they pass eastward through Ramsay, and follow the general course of Indian Creek, on the south side, towards the Mississippi River, where they are lost sight of beneath the Lower Silurian limestones. Through Ramsay the dip varies from 45° to vertical, but the thickness apparently remains about the same as that already given. When the banded structure becomes corrugated or wavy, the limestone much resembles the Arnprior marble. The limestone at Arnprior belongs to a band which is largely developed at the mouth of the Madawaska, in the township of MacNab, on the Ottawa River. Sir W. E. Logan, in describing it in the "Geology of Canada, 1863," page 823, says:—"In MacNab, on the Ottawa, there is a great extent of crystalline limestone, which is coloured of a bluish-grey, from an admixture of plumbago. This colour is irregularly distributed, some portions being nearly black, and others almost white, so that the rock often presents a striped or barred appearance. In many cases, however, the beds are very much corrugated, and sections of it exhibit curious complicated patterns like the grain of certain wood; the white, bluish-grey, and black colors, being arranged so as to give very pleasing effects." This limestone also contains, according to Sir William, a little tremolite. I give this quotation for the purpose of comparison, as it is very probable that the Lanark and Ramsay banded limestone, and the Arnprior striped, wavy and corrugated limestones, are both parts of the same great band. This fact, however, cannot be determined by actual observation, owing to the intervention of the uncomformable Lower Silurian rocks, which occupy the country from Ramsay to within a short distance of Arnprior. From the last outcrop of limestones in Ramsay, to Arnprior, the distance in a direct north line, is between twelve and thirteen miles. From Arnprior, they extend north-westward along the Ottawa River for some distance, and dip at a slight angle to the north-eastward. This north-eastward dip is pretty constant along the western side of the Ottawa River, through Horton and Ross; but in this direction, there occurs a great change in the strike of the rocks, from that existing in the Counties of Frontenac and Lanark. This has already been noted in Levant, (page 126) from which it will be seen that it affects a great thickness of strata. But to return to Lanark County, westward from Indian Creek, the northern boundary of limestones extends to the township of Darling, which it enters about lots one or two in the ninth concession. Here, the strike suddenly changes from westerly to south and south-westerly, and the dip abruptly from vertical to angles of from 30° to 45°. So very abrupt is this change in

Resemblance to the Arnprior marble.

Abrupt change of strike and dip in Darling.

the course of the rocks, that they appear at first sight to abut or run against the diorite hills of Darling township, which belong to Group III. From this position they extend south-westward through Lanark and Dalhousie in numerous undulations, and cover a very large part of both townships. In the seventh concession of Lanark, about three and a half miles westward from where they were first measured, they have a breadth of three miles and a half. Still further in this direction, on the line between Lanark and Dalhousie, another measurement showed them to occupy a width of four miles; while in the fourth concession of Dalhousie, they were found in undulations over a transverse measurement of three and a half miles. These measurements prove the limestones to be of great thickness, and, I think, support the estimate already given. Further to the south-westward, on the line between Dalhousie and North Sherbrooke, the band narrows to one mile and a half. This is caused by the protrusion of a mass of red syenite, or syenitic gneiss, which occupies a pear-shaped area in the south-eastern quarter of the last named township (see map). The band encircles this boss or dome of gneiss, from which the limestones appear to have been removed by denudation. On the north-western side of it, in North Sherbrooke, the limestones gradually thin out toward the third and second concessions, and are finally lost sight of. The dip, however, where last observed, was very slight, and to the south-eastward. A line of elevation, marked either by a broad, low anticlinal, or by protrusions of blotched and coarsely crystalline diorite, extends from the mass of red syenite, north-eastward through the centre of the limestone in Dalhousie and Lanark.

Syenitic gneiss.

Coarsely crystalline diorite.

As these singularly blotched diorites occur in close connection with the limestones, they may be noticed here. They were first observed at the northern extremity of the syenitic protrusion at Barber's Lake, a small sheet of water situated in lots three and four in the ninth concession of Dalhousie. In this locality they are very coarsely crystalline, and are composed chiefly of large masses of a greyish-black hornblende, and a white-weathering feldspar; mica and iron pyrites are also generally present. Further northward, in the eighth concession, they are not so coarsely crystalline. They are also seen crossing the Mississippi River, at its expansion, in the sixth and seventh concessions of Dalhousie, and are again very coarsely crystalline. Northward from this point, similar rocks occur immediately to the westward of Watson's Corners in Dalhousie and Hopetown, in Lanark township, where they vary in texture from coarsely crystalline to

Barber's Lake.

Dalhousie and Hopetown.

fine-grained. Lastly, they were observed in the vicinity of two small lakes in Lanark township, the first on the line between the seventh and eighth concessions, and on the twenty-second and twenty-third lots, and the second on the line between the sixth and seventh concessions on lots number twenty-four. Their further northward extension would carry them into the diorite region of Darling township.

Occurrence of banded limestones, south-west of N. Sherbrooke.

In conclusion, respecting the striped or banded limestones (1), I may state, that they again occur in a south-westward direction from North Sherbrooke, in Oso and Olden townships, and immediately to the southward of Cross Lake in Kennebec, also on the Addington Road in Kaladar, a short distance above the boundary line of Sheffield. Between these positions, however, there occur some intervals in which no limestone was observed. The distance from the exposures on the Addington Road in Kaladar to Arnprior on the Ottawa, is, as nearly as possible, seventy miles in a direct line.

Distribution of tremolitic limestones.

Estimated thickness.

(2.) *Brown-weathering Tremolitic Dolomite.*—These brown or blackish-weathering dolomites immediately overlie the banded limestones. Their general characters have already been given on page 141, where they are stated to be especially characterized by the abundance of tremolite they contain, and by their very rugged or jagged surfaces on weathering. I now wish to add some details respecting their distribution. The band or belt was closely measured at the same favorable point in Lanark as was chosen for the measurement of the banded limestones. The rocks are here in a nearly vertical attitude, and are well exposed along the line between the second and third concessions on lot twenty-one. From this measurement I estimate the thickness of the band to be from 1,000 to 1,600 feet. From its position on lot twenty-one, it extends eastward through lots twenty-one, twenty and nineteen of the second concession of Lanark, to the "Floating Bridge" over Taylors' Lake, whence it runs north-eastward through Ramsay. Through this township, the dip of the rocks continues steep, but their outcrop is often concealed by swamps. Consequently they do not form so marked a feature as in Lanark and Dalhousie, where they are exposed over wide areas. It will be an interesting point to investigate whether or not this zone of dolomite is represented at or around Arnprior, as, should such prove to be the case, we might be assured that the limestones of Lanark and Renfrew Counties were parts of the same great group. Westward from the point in Lanark where the band under consideration was measured, it is also influenced by the change in strike referred to when describing the distribution of the banded limestone (1) Through the western half of the twenty-first lot on the third, and eastern part of twenty in the fourth concession, they abruptly strike to the southward, with an eastward dip varying in inclination from 10° to 20°. This great lessening of the angle of dip causes the band to be much spread out, and it continues to form a conspicuous series of ridges to the south-westward through Lanark and Dalhousie. On lots eighteen in the eighth and ninth concessions of Lanark, a short distance to the northward of Mud Lake, it is very extensively developed, and presents the appearance of a series of rough jagged-weathering escarpments. At the village of Middleville, on the sixteenth lots of the fifth and sixth concessions, it forms a well marked ridge, which runs in an east and west direction, the rock dipping at an angle of 45° to the southward. From this position the course south-westward is marked by a series of swamps which extend to the Clyde River and Hopetown Road. On this road, however, through the eastern part of lot eleven in the eleventh and western part of lot twelve in the tenth concessions, they are again seen in great thickness. The stratification of the dolomite here is most distinctly marked by thin layers, or by thicker beds of white-weathering tremolite. The strata dip at angles of from 15° to 45° to the eastward. From this point they continue to run south-westward, in the direction shown on the map, through the eleventh and twelfth concessions of Lanark, and first, second and third concessions of Dalhousie; forming throughout a prominent ridge, or series of ridges. In places, particularly on the sixth and seventh lots of the first and second concessions of Dalhousie, the bedding is very slightly inclined, often approaching the horizontal, and the band is spread over an area of considerable extent. Further in this direction it reaches the U bend in the Mississippi River, on lots three in the fourth and fifth concessions, beyond which its further course through Dalhousie is concealed by heavy drift. It is, however, again extensively developed to the southward of the protrusion of syenite in North Sherbrooke, and occupies a large portion of the eleventh and twelfth concessions of South Sherbrooke. The dip here is at a much steeper angle than through Dalhousie, and there occur several repetitions of the banded limestones, which are probably due to sharp and overturned undulations in the strata. The band then passes into the township of Oso, where its course has been already pointed out in a former report (Report of Progress, 1873–74, p. 105). The following further details respecting its distribution may, however, be now given. On the twentieth lot of the sixth concession of Oso, the property of Mr. Davis, just at the line of junction with the overlying hornblende slate rocks, the rugged-

Low angle of di

Well-marked stratification.

Heavy drift.

ugged weathering character of e tremolitic olomites well own.

weathering character of the dolomite is particularly well shown. The strike here is north-eastward, and the dip south-eastward < 45°. From this point the dolomites extend transversely to their strike, north-westward to the rear of the twenty-fifth lot in the sixth concession, where they are bounded by an elevated area of syenitic diorite, or that variety of diorite in which a red feldspar (probably orthoclase) is largely intermixed. The dolomite here is nearly two miles wide, and throughout the dip is to the south-eastward, at an angle of 45°. There are, however, frequent alternations of thinly-bedded, banded limestones, which makes it probable that both bands are again and again repeated in sharp undulations. There are also interstratified bands of a white orthoclase rock or gneiss, which were not before met with in connection with the dolomite. The immediate junction of the dolomite with the syenitic forms of diorite, without the intervention of the schistose and slaty sub-division of the diorite group (III.), is a fact to be specially noted, as it seems improbable that in so short a distance as that from Dalhousie to this position in Oso, these latter rocks should so completely thin out. Bolton's Creek flows through the twenty-third lot of the sixth concession of Oso, and its further course south-westward is correctly laid down on the map which accompanies this report. This course may be said to represent as closely as possible the junction of the limestone and diorite rocks through the greater part of Oso. Towards the twentieth lot of the second concession, however, the latter rocks cross the travelled road between the townships of Oso and Olden, where they are chiefly syenitic. In this direction, and for a considerable distance into Olden, the syenitic rocks are the only ones seen, and they appear to graduate into syenitic gneisses.

olton's Creek—e line of junction between the olomites and orites.

The south-eastward limit of the dolomite extends from Davis's lot, twenty in the sixth concession of Oso, south-westward to the neighbourhood of the Narrows of Sharbot or Sharbard Lake, and is seen again in this direction on the long promontory on the western side of the same lake, on lots fourteen of the eighth and ninth concessions of Olden. Beyond this point there must be a great break, as the limestones and dolomites do not appear to reach the Godfrey Road, which runs through the centre of Olden, about five miles to the west of the promontory alluded to. On this road, however, a great series of speckled hornblende slates and schists, with some diorites, are met with, striking almost north and south, with slight dip eastward. These may represent the slaty and schistose sub-division of the diorite group. But this point will be better understood by reference to the map. I need only add that the same

obable break.

jagged-weathering band of dolomite is extensively developed on the road to and around Arden village, in Kennebec, south of Cross Lake, and thence south-westward to the Addington Road in Kaladar, a short distance north of the boundary-line of Sheffield. Further notes on its occurrence in these positions will be given in a future report.

Hornblendic rocks, their characters and distribution.

(3.)—*Hornblende Rock, Slate and Schist.*—These immediately succeed and overlie the jagged-weathering dolomites. Their general characters have already been given on page 142, where they have been shown to constitute four varieties. These varieties seldom occur together, but sometimes one, sometimes another of them marks the course of the belt. In Ramsay, they are well represented, both to the northward and southward of Indian Creek, on the greater part of its course through the township. The chief variety here is the very black massive, sometimes finely speckled, hornblende rock, which, however, in some places graduates into hornblende slate and schist. On lots nineteen and twenty of the second and third concessions, these slates and schists form a well marked belt or ridge. They are in part greenish-coloured, and resemble diorite slate, but the more schistose portions are of a greyish-black colour. Garnets occasionally characterize one or more divisions of the rock, and by weathering in relief give the surface of the beds a singular tubercled appearance. The rocks of this sub-division are much more extensively developed to the south-westward of Ramsay in Lanark, Dalhousie, Bathurst and South Sherbrooke townships.

On lots sixteen and seventeen in the eighth, and seventeen in the ninth concession of Lanark, they are seen to immediately overlie the jagged-weathering tremolitic dolomite. Here, they are largely greenish slates of a very fine and glossy texture which dip at a slight angle to the south-eastward. Above these are several bands of the coarsely crystalline, greenish-grey hornblende rock, with a little white-weathering feldspar, and calcite in cavities.

Fibrous or columnar diorites.

On lots fifteen and sixteen in the seventh concession of Lanark, the coarsely crystalline, and the fibrous varieties are represented. The fibrous variety presents everywhere a remarkable appearance, owing to its tendency to break into columns, or long splinter-like fragments, one blow of the hammer often being sufficient to detach a mass from three to five feet in length. The resemblance of these fibrous hornblende rocks to the columnar diorites of Elzevir and Madoc has been already remarked, and it may be mentioned that in the latter townships they are underlaid by green hornblendic and pyroxenic slates. South-eastward of the village of Middleville, through the thirteenth and fourteenth lots of the fifth and sixth concessions of Lanark township, the hornblende rocks are again well seen; but here the chief rock is the black massive variety. At the Clyde River, and on the sixth, seventh, eighth and ninth lots of the second concession of Lanark, there is another large development of these rocks, and they are again seen to rest immediately upon the jagged-weathering tremolitic domolite. From this point to their position in rear of Playfairville in Bathurst, they preserve much the same characters as have been already noted.

On lots one and two of the eighth and ninth concessions of Dalhousie, and in the adjacent portion of the twelfth concession of Bathurst, nearly the whole of the varieties of hornblende rock are represented, and their strike would appear to carry them against the protrusion of syenite, which has been previously described. They are next extensively met with in the centre and towards the western portion of the eleventh concession of South Sherbrooke, where the rock is a speckled garnetiferous hornblende slate, with transverse jointing, and of a deep rust-colour. From this position south-westward to the "Narrows" of Sharbot Lake in Oso, the rock is of the same rust-colour, and forms a particularly prominent and well-marked belt. At several points in Oso, its contact with both the underlying and overlying limestones was well seen, and, from a number of measurements made, I estimate its thickness at not less than 2,000 feet.

hickness of ornblendic ocks.

imestone above he hornblendic ocks.

Above this belt of hornblende rock and slate (3) is another of limestone and dolomite (4) similar to the dolomite (2) and the banded and striped limestone (1) already described. This has been referred to in previous reports as the Sharbot, Playfairville and Lanark band, but as it is only separated from the lower one by the comparatively narrow belt of hornblendic strata, there is no reason why both bands should not be considered as parts of one group. The upper band is largely developed throughout the whole of the eleventh concessions of South Sherbrooke and of Bathurst. Its banded structure is beautifully marked at and around Playfairville on the Mississippi, and at Lanark village in Lanark township, in both of which places it would furnish a very desirable stone for ornamental purposes or building. The Dalhousie iron mine is situated towards the base of this limestone, and not far to the rear of Playfairville. From Lanark village, north-eastward, the limestone extends along what is known as the Rosetta and Almonte Road, in the course of which it passes through Ramsay township, where, however, its banded character is not so marked. In both Lanark and

tone for rnamental or uilding urposes.

Ramsay townships it is immediately followed by the gneiss of the gneiss and limestone group (V.) yet to be described, and approaching this gneiss, it frequently becomes interstratified with subordinate masses of red feldspathic rock. It may be noted here that the deposit of hematite in MacNab township, near Arnprior, occurs in a similar striped and banded limestone.*

V.—Gneiss and Crystalline Limestone Group.

Position of rocks of Group V.

In the rocks constituting this group the dip is pretty uniform, and constant in direction, and the respective belts have distinctive characters, by which they may be followed for considerable distances. They immediately follow, and *apparently* overlie the banded limestones, tremolitic dolomites and hornblende rocks of Group IV.; but whether they really do so is, of course, dependent upon the correctness of the interpretation of the very complicated arrangement of these rocks. Group V. is a very wide-spread one, and what I have to state at present refers more especially to the distribution of its lower portion, or that which occupies the front third of Lanark County. This embraces the three uppermost of the bands of limestone mentioned in my last report (Report of Progress, 1873-74, p. 104)—namely, the Lower Sharbot Lake, Maberly and Bennett's Lake band (3), the Crow Lake, Rock Lake and Silver Lake band (4), the Bob's Lake, Tay River and Meyers' Lake band (5); as well as the other small and still higher band of limestone mentioned in the Report of Progress, 1872-73, p. 160, —namely, the Farren's Lake band (6). These limestones, along with the associated gneisses, occupy a belt of from ten to twelve miles in width, which immediately borders upon the south-eastern boundary of Group IV., through the whole south-eastern part of Lanark County. To this group belong the bands of serpentine limestone, the more important of the iron ore and plumbago deposits, and towards its summit the great beds and veins of apatite—the three last minerals being probably indicative of the presence of both animal and vegetable life during the period of deposition. This, though important, is but one step gained, and we have yet to determine the position which these rocks occupy in relation to other portions of the Laurentian system, and to the Huronian or other pre-Silurian formations.

Lower portion of the group.

Minerals indicative of organic life.

The detailed characters of the rocks of Group V. are best seen in the

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* Subsequent exploration has shown that the sub-division (3) represents the upper portion of Group III. brought in by an overturned anticlinal fold, and consequently that the limestone (4) is a repetition of (1) and (2).

Good exposures of the rocks of Group V.

south-eastern half of Oso, southern three-quarters of south Sherbrooke and western half of Bathurst townships, beyond which they are concealed, first by deep drift and then by the Lower Silurian strata in Drummond and Beckwith. In Lanark and Ramsay, however, a portion of their north-western outcrop is further exposed for a short distance; but this again becomes covered on approaching the line of the Brockville and Renfrew railroad, through the eastern portion of this last township. They appear to occur in the following ascending order:—

Section.

	SURFACE MEASUREMENT.*	
	Ft	Angle of Dip.
1. Red orthoclase gneiss, and hornblendic strata, the latter showing transitions into diorite....................	3,900	40° to 60°
2. White and highly crystalline serpentine limestone of the Maberly and Bennet's Lake band, divided into two or more beds by interstratified hornblendic gneisses. In the limestone the serpentine is abundantly disseminated in lumps and irregular grains; chrysotile in veins, and graphite in scales, are nearly always present.	2,600	40° to 60°
3. Hornblendic gneiss, apparently containing two species of feldspar, and showing transitions into gneissoid and granitoid diorites; containing also a great deal of epidote in grains or layers, and in places crystals and irregular grains of magnetite. The transition forms of rock are of endless variety. In this division there are some unimportant bands of a sandy crystalline limestone; these occur irregularly, and are not marked by serpentine............................	5,500	60° to 80°
4. A white-weathering rock, composed very largely of a white feldspar (oligoclase ?), quartz, and a dark-greenish black hornblende. The hornblende occurs in finely disseminated crystals, marking the stratification, and in aggregations, streaks and patches of various forms. This rock is peculiarly characteristic of this horizon. The feldspar very largely predominates, and gives a chalk-white aspect to the weathered surface of the rock....................	1,500	45° to 80°
5. A coarsely crystalline white limestone, with graphite, iron pyrites, and scales of brownish-yellow mica, divided into several beds by interstratified masses of rusty orthoclase and quartz rock. This constitutes the Crow Lake, Rock Lake and Silver Lake band of lime-		

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* Surface measurement is here given, rather than the usual estimate of thickness of the respective rock masses; as in a region in which the strata are so often repeated in minor anticlinals and synclinals, such an estimate would probably greatly increase the true thickness.

		Ft.	Angle of Dip.
	stone. (Report of Progress, 1873-74, p. 104.) Serpentine was not observed in it	2,600	60°
6.	A great body of red and dark coloured hornblendic gneiss, and hornblende rock or diorite,—as yet but imperfectly investigated. Towards its summit it becomes interstratified with small bands of crystalline limestone, and some large deposits of magnetic iron ore.	7,900	45° to 60°
7.	A very coarsely crystalline white limestone, containing mica, graphite and chondrodite, interstratified with coloured quartzites, and dark hornblendic bands of rock. This is the Bobs' Lake, Tay River and Meyers' Lake band, which immediately overlies the second ferriferous horizon. (Loc. cit.)	2,600	45° to 80°
8.	Red granitic and dark hornblendic gneiss	2,600	45° to 80°
9.	A small band of white highly crystalline limestone of much the same character as the preceding, and seldom exceeding two chains in width. This is the Farren's or Sherbrooke Lake band. (Loc. cit., p. 106.)	60-100	60° to 80°
10.	Hornblendic strata, with deposits of magnetite, and red orthoclase gneisses	1,300	80°
11.	Red orthoclase gneiss, in which the stratification is clearly marked. Towards its summit it becomes thin-bedded and fissile, and has interstratified with it beds of a pure flesh-coloured calcite, in which black spinel occurs rather abundantly. This mineral also is found in the crystalline limestones of northern New York, where in many places the rocks strongly resemble those of North Burgess and Bathurst	3,000-5,000	80° to 40°

Position of apatite-bearing rocks.

Higher still in the series than eleven, another calcareous belt occurs, and, immediately above it, the true apatite-bearing rocks come in, in shallow and often overturned trough forms. These constitute the sixth or highest of the groups of rocks, and have been described in the Report of Progress for 1872-73, p. 160. *et seq*.

Constancy of strike and dip.

Section probably a sequence of rocks in ascending order.

Throughout the whole of the eleven zones or belts of rock which together constitute Group V., the strike is constant in a north-easterly direction, the dip being steady to the south-eastward; and although the characters of some of the rocks in two or more of the belts are alike, there appear to be sufficient grounds for assuming that the foregoing section correctly represents a sequence of the rocks in ascending order. This probability is further strengthened by what has been already stated on page 122 respecting the three distinct horizons of iron ore which occur in proximity to the three apparently stratigraphically distinct bands of limestone. On the other hand, the statement made by Sir W. E. Logan, in the Report of Progress, 1853 to 1856, page 8, when referring generally to the Laurentian strata, may still be applied to the rocks of this group. Sir William says:—"It is scarcely possible to know, from mere local inspection, whether any mass of the limestone in one part, is equivalent to a certain mass in another. They all resemble one another more or less, lithologically, and although masses are met with, running for considerable distances rudely parallel to one another, it is not yet certainly known whether the calcareous strata are confined to one group, often repeated by sharp undulations, or whether, as is probable, there are several groups separated from one another by heavy masses of gneiss."

Extract from a report by Sir W. E. Logan.

In the township of South Sherbrooke, the whole of the rocks of Group V., as given in the foregoing section, are represented. A high belt of country to the north of the Fall River and Maberly village, is occupied by the red gneiss and associated hornblendic strata 1. Immediately along the course of the same river, and a short distance to the north of it, are the spotted serpentine limestones 2. These could not be distinguished from the limestones of Grenville, on the Ottawa. They abound in veins of chrysotile, and the surface of the mass presents a very rugged appearance from the weathering out of the grains and lumps of serpentine. This mineral, however, does not in general mark the stratification of the limestone, and no forms comparable to *Eozoon* were observed. The limestone has a very different appearance from the serpentine limestones described on page 138, as occurring in the diorite and hornblendic schist of Group III, in Dalhousie, where forms resembling *Eozoon* were detected in a number of instances. Both limestones, however, are closely associated with crystalline diorites. South of the Fall River, and extending towards Silver Lake, we have the hornblendic gneisses, gneissoid diorites, and white-weathering gneisses 3 and 4, characterized in many places by disseminated grains and crystals of magnetite, and towards their summit holding interstratified masses of crystalline magnetite and apatite, belonging to the lowest iron ore horizon. Next in succession, we have the Silver Lake band of limestone (5), occurring immediately to the northward of Silver Lake, and then the third volume of gneiss (6), extending southward to within a few chains of the Tay River. The Meyers' Lake and Silver Lake deposits of iron ore are near the summit of this gneiss, and constitute the second ferriferous horizon, followed successively by the remaining members of the group (7-11). These have been referred to in an early part of the present report, and in previously published reports, when speaking of the distribution of the iron horizons.

Serpentine limestone.

No *Eozoon* observed.

Magnetite and apatite.

Second ferriferous horizon.

Bathurst. In Bathurst, the only portion of Group V. that is clearly seen is that including and below the Silver Lake band of limestone; the higher members being either concealed by a flat cultivated country, by swamps, or by the horizontal sandstones of the Potsdam formation. Drummond. In Drummond, the greater part of the township is covered by the Lower Silurian sandstones and limestones, but the lowest gneisses of Group V. occur in its extreme north-western corner, and chiefly between the Clyde and Mississippi Rivers. Lanark. In Lanark township, the lowest gneisses (1) are extensively met with immediately to the eastward of Lanark village, whence they continue to form prominent hills in a north-eastward direction, and to the south-eastward of the Rosetta Road, up to lots twelve and thirteen on the twelfth concession line of the same township. On these lots the gneisses (1) are suddenly deflected from their north-easterly course to an east and west one, and are carried by this turn into Ramsay township, Ramsay. where, on lots eleven and twelve in the second concession, they are again well developed. From this position they resume their north-easterly course, and were traced up to lots fourteen and fifteen in the fifth and sixth concessions of Ramsay. On this part of their distribution, namely, from the second to the sixth concession, the rocks form a hilly and unfertile belt of country, known by the name of the "Wolf Grove," Wolf Grove. which extends also north-eastward to the Almonte Road on lot seventeen in the seventh concession. Width of gneiss. The width of this belt of gneiss (1) through Ramsay was measured in several places, and found to average one mile. I believe it very probable, however, that it occurs as an over-turned anticlinal, the dip being constant to the south-eastward; and if so, then the limestones and hornblende rocks of Group IV. must occur in a trough or synclinal form. Immediately overlying the gneiss of 1, to the south-eastward through Lanark and Ramsay, we find the serpentine limestones of 2, and hornblendic gneisses of 3. Serpentine limestone. The serpentine limestones were first met with south of a small lake in the eighth lot of the ninth concession of Lanark, whence they were traced to the centre of the ninth lots in the same, and in the tenth concession. Beyond this position they were lost sight of under heavy drift; but in Ramsay, on the ninth lot of the second concession, limestone was again found, abounding in a beautiful amber-coloured serpentine. This is undoubtedly a continuation of the same band (2), as it occurs in the same position relatively to the red gneiss 1. From the ninth lot of Ramsay, serpentine limestone continues to the front of lot thirteen in the seventh concession, its course for this distance (four-and-a-half miles) being parallel to the south-eastern limit of the gneiss 1. It is underlaid by a very

Hornblendic gneiss, 1,800 feet thick.

black massive hornblendic gneiss, from which, however, it is separated by one or two minor bands of a deep rust-colour. Beneath this black hornblendic gneiss, which has a thickness estimated at 1,800 feet, there occurs another small band of limestone which seldom exceeds thirty feet in thickness, and was only observed through Ramsay; its small dimensions, however, probably have caused it to be overlooked in Lanark, Bathurst, and South Sherbrooke. It is not characterized by serpentine. From the position of the serpentine limestone (2) on the Fall River in South Sherbrooke, to the position in which it was last seen on the thirteenth lot of the seventh concession of Ramsay, the distance is about twenty-nine and a half miles, and along this whole course it is closely followed by the hornblendic gneiss and dioritic rocks of 3. These last, however, become of a somewhat different character and appearance in their north-eastward distribution through Lanark and Ramsay, which is caused by a diminution of the feldspar, and the entire absence of the epidote. Consequently, in the two townships just named, the rocks of 3 are chiefly dark (almost black), fine-grained, hornblendic gneisses, which towards their upper portions graduate into black or brownish-black hornblende slate. On the other hand, in a westward direction from South Sherbrooke, these same hornblende rocks (3), associated with serpentine limestone (2), become very largely characterized by a yellowish-green epidote, and graduate into a rock which may be correctly termed an epidotic hornblende schist. This fact is interesting as it illustrates how local changes may entirely alter the general character and appearance of a band of rock, and to such an extent that it would, without stratigraphical evidence, hardly be recognized as the same. Through the south-eastern quarter of Lanark the measures are much concealed by swamps and heavy drifts of sand, and it was found difficult to determine with certainty which of the divisions of Group V. above 3 were represented. The dark hornblendic gneisses of this last division, however, are very largely displayed immediately to the south-eastward of the serpentine limestones (2) in the ninth and tenth concessions—namely, through lots five, six and seven in the former, and six, seven, eight and nine in the latter. Beyond these lots to the south-eastward, the whole country falls off in low ground towards the valley of the Mississippi River in Drummond township, where, in the immediate vicinity of the river, are great areas of submerged lands, which extend along the town line of Lanark in a westerly direction to within a short distance of Lanark village. Beyond this river, and to the southward,

Thin band of limestone.

Epidotic hornblende schist.

Large areas of submerged lands.

the Lower Silurian sandstones cover a large area. Going down the line between concessions eleven and twelve of Lanark, from the middle of lots nine to lots four inclusive, alternations of ridges of rock and swampy valleys are crossed. The ridges are all composed of the dark hornblendic gneisses, and the valleys in some instances would appear to be occupied by crystalline limestones; but how these last are related to those belonging to divisions 5, 6, 7 and 9, of Group V., I cannot at present venture to say. Towards the south-eastern quarter of lot three, in the twelfth concession of Lanark, is the limit in this direction of the dark hornblendic gneisses. They are followed by an important band of white crystalline limestone abounding in serpentine of a pale yellow or amber colour, which was also extensively met with through the adjoining lot—namely, three in the first concession of Ramsay, where the serpentine was particularly abundant, and in places was clearly interstratified in the limestone. Here an excavation had been made in the band for stone for the supply of a lime kiln close by, and I had a good opportunity of examining a great number of large and freshly-blasted masses of the rock. These showed a great diversity in the arrangement of the serpentine. In some parts the mineral occurred entirely as disseminated grains through a pure white and saccharoidal carbonate of lime. In others it was distributed in lumps or patches from the size of an ordinary bullet to that of a medium-sized cannon ball. Again, the serpentine was interstratified with the limestone, and formed a rock of striking beauty. Some forms resembling *Eozoon* were observed in this limestone, but most of them were on so large a scale that, upon breaking the rock into pieces, the fragments containing the supposed structure hardly sufficed to give an idea of any definite arrangement of the mineral. I, however, sent a small box containing the best of these to Dr. Harrington, for chemical and microscopic examination. The distance of this outcrop of serpentine limestone from that already described as occurring on lot nine in the second concession, is about two miles and a quarter, and as this is likewise the distance between the limestones of divisions 2 and 5, in South Sherbrooke, it might be inferred that the serpentine limestone through lot three in the first concession of Ramsay, held the same stratigraphical position as 5 in South Sherbrooke. But 5 in South Sherbrooke is the Crow Lake, Rock Lake and Silver Lake band, which is highly graphitic, and does not, in so far as examined, contain serpentine, while that in Ramsay, as we have just shown, is particularly characterized by this mineral. Further, in Ramsay

Ridges of hornblendic gneiss.

Serpentine limestone.

Forms resembling *Eozoon*.

there are indications of a north-westward dip in the limestones on lot three, which would suggest the possibility of a synclinal form between them and the outcrop on the ninth lot of the second concession. This, however, I found it impossible to determine, owing to the covered condition of the country north-eastward through Ramsay; while in a south-westward direction from lot three in the twelfth concession of Lanark, the course of the limestone carries it under the swamps of the Mississippi River. It was, however, traced through Ramsay to the side line between lots five and six of the third concession, where it is still upwards of two miles distant from the northern outcrop of serpentine limestone. Beyond this outcrop of serpentine limestone, in lots one and two of the first and second concessions, and lots two and three in the third and fourth concessions of Ramsay, red gneiss surmounted by bands of very rusty hornblende rock have an extensive spread, the latter keeping pretty much along the course of the road to Carlton Place from the first to the fourth concessions. Several deep rust-coloured belts of rock were observed in a number of localities through the southern part or front of Ramsay, and it is possible that these may mark the course of one or more of the ferriferous horizons of South Sherbrooke; but I am not aware of any trustworthy discoveries of iron ore having as yet been made.

Gneiss and hornblende rock.

From the middle of the eighth concession of Ramsay and eastward, the horizontal members of the Lower Silurian conceal the further distribution of the rocks of Group V.

The Geological Horizon of Eozoon.

In the section through North Burgess, given on page 111 of the present Report, I have shown the position in which the specimens of *Eozoon* were found. It will be observed that they occur immediately at the base of a band of crystalline limestone which lies beneath the greater part of the Burgess apatite-bearing series. This position is very similar to that in which the fossil occurs in Grenville, and in both places it is associated with pyroxenic strata and serpentine. More recently again, *Eozoon* has been found to occur in the township of Dalhousie in a serpentine and graphitic limestone associated with the dioritic and hornblendic rocks of Group III., and not far removed from the base of the Lanark limestones of Group IV. How these last, however, are related to the Burgess limestones, we cannot at present state with any degree of certainty.

***Eozoon* found in limestone below the apatite-bearing series.**

GOLD, COPPER, GALENA, AND PLUMBAGO.

In the second and third divisions or sub-sections of the present Report, allusion has been made to the apatite deposits, and to the occurrence of magnetite in the region examined. The following remarks, however, relate to such economic minerals as are not so frequently met with in this region, and which, consequently, are second in importance; namely, gold, copper, galena and plumbago. But before mentioning these I wish to record the occurrence of apatite in a new location which has recently come under my notice. This is on lot two in the twelfth concession of Bedford, and between the waters of Buck Lake and Devil Lake. The greater part, perhaps, of this lot, is occupied by the waters of Buck Lake, but in the western half of the lot, a hill or ridge of reddish orthoclase gneiss, with garnets, occupies a small area. In this a very beautiful, greenish-blue, translucent apatite occurs as a bed. It is remarkably free from impurities, such as calcite and mica, and although specimens have not yet been analysed, I am convinced, from its appearance, that it is of a very superior quality. Its position is precisely the same as that of the Black Lake deposits in North Burgess, on the long promontory which forms portions of lots nineteen, twenty and twenty-one, in the sixth concession. In both places there is an underlying and overlying band of white crystalline limestone, and garnets characterize the intervening gneiss. The strike of the gneiss on lot two in Bedford is to the north-eastward, with south-eastward dip, at the comparatively slight angle of 20–30°. With this strike and dip it extends south-westward into Loughborough, where it forms the whole of the long strip of land which divides the eastern from the western arm of Buck Lake. On this lake the position of the two adjacent bands of limestone is definitely marked by the two arms or bays of the lake. Apatite occurs in a number of localities in the promontory, all of which are beyond a doubt in the same horizon as the one to which we have referred in Bedford. It is an interesting and important point to note in this connection, that the Buck Lake deposits appear to be in a position corresponding to those on the south-eastern side of Opinicon Lake, in the first lot of the seventeenth and eighteenth concessions of Bedford, between which positions a synclinal form exists. The distance between these deposits of apatite is close upon five miles, and this may be said to represent the widest part of the trough. From the two opposite positions, the apatite-bearing rocks converge in a south-

New apatite location.

westward direction, until in Loughborough, and towards the southern extremity of Buck Lake, they are only one mile apart. This is another strong point in confirmation of the bedded character of these deposits, and as the occurrences of the mineral are frequent along these lines of outcrop, it is not unnatural to conclude that there must be a nearly continuous zone or layer of the mineral throughout the horizon from one side of the synclinal to the other. Now as it happens that the opposite dips are here at a small angle, it follows that this layer, if I may so call it, could be reached at a comparatively slight depth at many points between Opinicon and Buck Lakes. The truth of this conjecture might easily be tested, and with no great outlay, by a series of borings along the town line of Bedford. It is impossible to state what would be the result, but I am very favourably impressed with the idea, and think it would be well worth a trial, in the manner suggested, by any one interested in the development of the apatite deposits.

Bedded character of apatite deposits.

Boring recommended.

Gold and Copper.—Copper ores and gold are intimately associated in the localities to which we have now to refer, and consequently may be considered together. They occur invariably in beds and veins which are connected with a belt or group of rocks, referable to the Hasting's series and its equivalent, Group II. of the foregoing report. In Belmont, at the extreme north-western extremity of Deer Lake, on the land portions of lots thirty-one and thirty-two of the first concession, the yellow sulphuret of copper occurs in lumps, strings and veins, in the green slates and grey magnesian limestones of the Hastings series, but in no one place in sufficient quantity to be profitably worked. Gold also was found by analysis in some of these ores, but only in traces. In Lake township, where the diorites, green slates, dolomites and mica slates, are very extensively developed, copper ore occurs in a great number of localities, and with it gold is always intimately associated. In Tudor, it occurs in a chloritic schist, associated with the speckled diorites of an abrupt ridge which crosses the Hastings Road a short distance to the north of the River Jordan, and which is well known as the "Hole in the Wall." It also occurs in small quantity in the bands of greenstone which are interstratified with the grey limestones in this township. In Madoc the occurrences of copper ores are numerous, and we find besides the ordinary yellow sulphuret, the variegated or purple copper ore, and the rarer tetrahedrite or grey antimonial copper ore. At the Richardson gold mine, on lot eighteen in the fifth concession, both the yellow and purple ores of copper are associated with the greenstone which occupies the western portion of the

Intimate association of gold and copper.

Belmont.

Lake.

Tudor.

Madoc.

lot, while towards the centre of the eastern portion, gold was at one time obtained in large quantities from the *gossan* which filled the crevices in a very cavernous ferruginous dolomite. Here it was also closely associated with white finely granular mispickel or arsenical pyrites, through which yellow sulphuret of copper was disseminated. At the Empire mine at Madoc village, and close to the new Episcopal Church, tetrahedrite was found irregularly distributed through a very siliceous brown-weathering dolomite, and was both auriferous and argentiferous, some of the analyses indicating large percentages of both gold and silver. (See Report 1866–69, pp. 168 *et seq.*) Gold.

In Marmora, copper ore was found in traces in a number of localities along the western margin of the granite area known as the "Huckleberry Rocks," and here it was associated with mispickel which is highly auriferous, but contains little silver.

In Elzevir, in the vicinity of Bridgewater, copper ore again occurs in a number of places, and also gold in small quantity. In Kaladar, in the neighbourhood of Flinton village, the green diorites and slates are traversed by numerous veins of milky white quartz, and these in a number of instances carry the yellow sulphuret of copper. In Barrie, along the Addington Road, in similar green diorites and slates, copper ore occurs in a great many localities, but in inconsiderable quantity. Elzevir, Kaladar, and Barrie.

In the south-eastern corner of the township of Palmerston, a rather important vein, carrying a large proportion of copper pyrites, was met with on the west half of lot two in the ninth concession. It is closely associated with dark-greenish hornblende rocks, and some glossy and rusty mica slates, and the gangue is largely composed of translucent quartz, which appears to be divided into layers by intervening strings of iron and copper pyrites. Calcite also occurs abundantly in bunches and layers. I was informed by Mr. Oliver, of Perth, who is interested in this location, that gold was found by analysis to be present in sufficient quantity for profitable extraction. No analyses of the ore have yet been made in the Survey laboratory. Palmerston.

In Levant, veins holding copper ore were at one time worked in a number of localities, and considerable interest was directed to this township while the mining continued. On lot six, in the seventh concession, copper ore occurs in layers associated with thin seams of chlorite and quartz. The quartz layers vary from one quarter of an inch to three or four inches in thickness, and are separated by the seams of chlorite; both the chlorite and the quartz contain sulphuret of copper. These together form a cupriferous zone or belt, averaging, perhaps, four feet in thickness, Levant.

which has been traced for a few hundred yards in a north and south direction. On this belt, in the lot just referred to, a shaft has been sunk; but it did not result in developing anything of importance. Copper again occurs on lot eight in the seventh concession, in a fine-grained, bluish-grey magnesian limestone. The ore is distributed in bunches or aggregations of sulphurets with quartz in nests, and is also scattered in a very irregular manner along the course of the band. Iron pyrites is intimately mixed with the copper ore. It is again found on Mr. Browning's property, lots five and six, in the seventh concession, where it occurs in a grey and very siliceous magnesian limestone. Here several openings were at one time made, and a considerable quantity of copper ore obtained, most of which, however, was extracted from within a few feet of the surface.

From the lots just mentioned, the cupriferous belt runs in a northerly direction through Levant to the foot of Joe's Lake, on lot thirteen in the fourth concession, where it again contains traces of the ore. The rocks here are drab dolomites and green chloritic slates. Still further northward, these rocks pass into the township of Darling, on lot eighteen in the first concession, where, on Mr. Elliott's farm, copper ore is again associated with brownish dolomites and blotched diorites. In Darling copper ore occurs in innumerable localities in rocks of similar characters, but nowhere, so far as known, in remunerative quantities. It is my impression that throughout the whole of this region the ore occurs in too irregular and scattered a form to ever permit of its being extracted with profit.

Darling.

Native copper was found in one instance by myself in a quartz vein, enclosed in a band of diorite, in the township of Marmora. The metal occurred in the form of brilliant plates or scales on the surfaces of a series of joints in the quartz which run transversely to the stratification of the enclosing and adjacent rocks. These scales of native copper could easily be detached from the quartz with the point of a penknife, and beaten out into very thin plates.

Marmora.

Lead ore.

Galena.—The mining of this ore of lead in Eastern Ontario, up to the present date, has not been attended with favourable results, and, as in the case of the apatite deposits, I have now to report an almost entire suspension of mining operations. That failure has been largely due, in many instances, to the very improvident manner in which mining has been carried on, there can be no manner of doubt; but it must be added, that in a number of instances, galena-bearing lodes, which, on their first discovery, and even for a considerable time afterwards, were of the greatest promise, have since proved, under systematic mining, to be of little value, and have consequently been abandoned. Such was the case with the "Ramsay Lead Mine," in Ramsay township, Lanark County; the Bedford galena lodes; many of those in Loughborough and Lansdowne, in Frontenac; as also those in Tudor and Lake townships in Hastings, and Methuen in Peterborough County. Arrangements, however, are again in progress for the re-opening of the extensive galena lode at the Frontenac mine, on the south half of lot sixteen, in the ninth concession of Loughborough township, and, from what I can learn, work will shortly be commenced. In another locality in Lansdowne, work is at present progressing on a lode which runs parallel to that at the Frontenac mine just referred to; but not having visited this, I am not in possession of particulars respecting it.

Ramsay mine.

Frontenac mine.

From the facts I have been enabled to gather respecting these galena lodes, it would appear probable that they are more closely connected with the Lower Silurian formation than with the Laurentian, and that it is in the former that they reach their greater development. They, however, undoubtedly, extend downwards for some distance into the Laurentian; but then perceptibly diminish in their mineral contents, and in the greater number of instances become unproductive. This fact is clearly illustrated at the Ramsay lead mine, in Ramsay township, where the magnificent lode, as first observed and worked in the Calciferous formation, was from two and a half to five feet in width; the ore-bearing portion being from eight to twenty-four inches. In its downward course through the Potsdam, however, the lode, though still retaining its general width, carries less and less ore, and finally, upon entering the Laurentian, becomes too irregular to be worked with profit. The general bearing of this lead vein through lot three in the sixth concession of Ramsay, is N. 50°—55° W., or nearly in the direction of the concession lines. In this direction, however, we almost at once come upon the crystalline and upturned Laurentian rocks; consequently, if further search is made, it should be to the south-east of the old workings, in which direction there is no reason why the lode should not be as productive as where it was first mined. There is, perhaps, however, a possibility of higher members of the Calciferous, or immediately succeeding formations, capping over and concealing the lode in this direction.

Position of galena lodes.

Plumbago.—Notwithstanding the fact that all the crystalline limestones of Frontenac and Lanark Counties are more or less graphitic, workable deposits of plumbago have only been met with in a very few

Plumbago.

instances, and the whole of these at or close to the summit of the Laurentian series, and in association with the apatite-bearing rocks. In Frontenac County, for example, plumbago first occurs in considerable quantity in portions of Bedford and Loughborough, in one of the highest bands of limestone yet met with. In Lanark it again occurs in the extension of the same limestone in North and South Burgess and North Elmsley. (See Report of Progress, 1872-73, p. 178). To the northward of these positions, it has only been found in very small quantity. During last summer's investigations, I examined a reported plumbago location, situated on the ninth lot of the ninth concession of Lanark township, on the property of a Mr. Tennant. Here the mineral was found in mere traces, scattered around a small opening which had been made in a band of serpentine limestone. Its occurrence in connection with such a limestone is interesting, but the deposit is of no economic importance. In other parts of Lanark and Ramsay, similar irregular deposits of plumbago occur, but none of those known are worth considering. Assuming, then, that the Loughborough, Bedford, Burgess and Elmsley crystalline limestones and associated gneisses, are the true plumbago-bearing rocks, it becomes a matter of interest to correlate them with those of other regions. The distribution of these rocks in Frontenac and Lanark Counties is limited both to the south-westward in Portland, and to the north-eastward in Elmsley township, by the flat sandstones of the Lower Silurian, which lap over and conceal them; the lineal extent of the area along which the former are distributed being only about twenty-six miles. Following on what may be considered as their general course from Elmsley, we pass over a great flat area of the Lower Silurian sandstones and limestones, in Beckwith, Goulburn and Nepean townships, to a position on the Ottawa River, nearly opposite Hull. But immediately upon crossing this river, the lower crystalline rocks are again exposed, and are seen to extend north-eastward through Hull, Templeton, Buckingham and contiguous townships. Amongst the first exposures of the crystalline rocks met with in the vicinity of Hull are those containing the magnetic iron deposits, and in which we find plumbago, not only in the hornblendic gneiss and crystalline limestone, but also in the iron ore itself. Farther on, in Templeton and Buckingham, limestones are met with abounding in plumbago, in the form of thickly disseminated scales, interstratified layers and more extensive masses.

Frontenac and Lanark.

Its occurrence in these townships, in a position corresponding to an extension of the line of strike of the Loughborough, Burgess and Elmsley rocks, is interesting, and although little stratigraphical work has yet been done here, sufficient facts have been collected to prove that the crystalline limestones in which the deposits of plumbago occur are arranged in troughs or synclinals, like those of the Burgess region. Beneath these, and often separating them, in Buckingham, there occur great volumes of pyroxenic and orthoclase strata, in which apatite has recently been found to exist in large workable masses. Such rocks are largely developed along the left bank of the Rivière du Lievres, and on lots eighteen to twenty-one of the twelfth concession, while to the southward, and in a position which would appear to be immediately above these, I have succeeded in tracing a belt of rocks containing plumbago for several miles. These apatite-bearing rocks of Buckingham are precisely the same in their general character as those in North Burgess and Elmsley, and in them the apatite occurs in the same conditions, namely, as bedded masses, irregular veins, and aggregations of crystals in a matrix of pink carbonate of lime. In Grenville, again, the plumbago occurs in connection with the Grenville band of limestone, which, as you are aware, lies in a series of irregular troughs. In this band, as in North Burgess, mica also occurs in crystals of sufficient size to be of economic value, and the stratigraphical position of these, as laid down by Sir W. E. Logan, agrees closely with those in Burgess. Thus it is extremely probable that plumbago, (in workable deposits) mica and apatite, all characterize the highest belt of crystalline limestone yet recognized.

Apatite in Buckingham.

Mica.

Molybdenite.—A beautiful hand specimen of this mineral which had been mistaken for plumbago, was shown me by a minister in Levant, who had just returned from one of his circuits in the township of Matawachan. The precise locality from which it was derived could not be ascertained, but from what I could gather it was from the township of Matawachan, and not far from the valley of the Madawaska River.

Molybdenite.

I have the honor to be, Sir,
Your obedient servant,
HENRY G. VENNOR.

GEOLOGICAL SURVEY OFFICE, *May*, 1875.

NOTE.—Since writing the preceding Report, further investigation has considerably added to our knowledge of the stratigraphical position and distribution of several of the groups of rocks mentioned, and it has been thought expedient to give the additional facts collected, on the accompanying coloured geological map This map consequently, is somewhat in advance of the Report.

REPORT

ON

EXPLORATIONS AND SURVEYS IN CAPE BRETON, NOVA SCOTIA,

BY

MR. CHARLES ROBB, C.E.,

ADDRESSED TO

A. R. C. SELWYN, Esq., F.R.S., F.G.S.,

DIRECTOR OF THE GEOLOGICAL SURVEY OF CANADA.

Area examined.

SIR,—In the prosecution of the work of the survey in Cape Breton, it has appeared desirable, for reasons which have been stated in previous reports, to complete the investigation of the Eastern or Sydney coal field, before entering on that of the underlying rocks.

Accordingly, during the past season, my attention has been devoted chiefly to that object, and I have now the honor of presenting a report and maps which, with the facts given in previous reports, embrace the whole of the results arrived at respecting the carboniferous rocks in that part of the island.

The superficial extent and general topographical features of the region examined, have been already indicated. (Report of Progress, 1872-73,*) It has also been stated that numerous natural sections of the strata are afforded by the sea cliffs. These are more particularly referred to in the report for last year, where an account is given of the methods adopted, and of the progress made, up to that date, in measuring and recording them. During last season this work has been completed over the entire field, as far as the base of the Millstone Grit.

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* It is stated in that report (p. 240) that the highest altitudes rarely exceed 150 feet above the sea. I desire here to correct that statement, the maximum height being about 250 feet.

These natural sections extend over a distance of about sixty-five miles, or at least *twice* the entire length of the coal field. About 4,000 measurements were made of individual strata composing the various sections, and the aggregate thickness thus measured in 1873 and 1874 is approximately 24,500 feet. This, of course, represents far more than the actual thickness of the measures, as the same beds are exposed and were measured in several sections. Measurements.

From the number and proximity of the seams, great care is requisite in placing the positions of the shafts and trial-pits correctly on the maps; and in ascertaining as nearly as practicable their several elevations above the sea. For these purposes, and for the construction of an accurate topographical map, it was found necessary to traverse most of the roads throughout the whole region, and to follow various lines of borings and trial-pits, sometimes through exceedingly rough wooded country.

This work, together with the traverse of the coast sections, I had previously done to a certain extent, and more or less accurately, by pacing, micrometer telescope and prismatic compass; and in some instances reliance was placed on the topographical accuracy of maps obtained from various sources. These methods, however, having proved unsatisfactory, and many additional openings, and other points of importance, having been subsequently recognized, I have during last season re-surveyed most of these lines, as well as many others, with the compass and chain, the total distance thus measured during the two seasons being 405 miles.

Two general maps have been constructed, showing respectively the part of the coal field and adjacent country to the east and to the west of Sydney Harbor; these maps are on a scale of one mile to an inch, and can be joined to form a single sheet if required. A small, but extremely interesting section of the field, namely, that at Kelly Cove, referred to in previous reports, is shown on a special map, drawn to a scale of four inches to a mile. Maps.

The report is further illustrated by a sheet of vertical sections of the strata. The scale of these is much too small (400 feet to an inch) to admit of showing more than the coal seams, and a few of the most characteristic beds. The larger manuscript sheets from which they are compiled, and which are described at page 178 of the Report for 1873-74, will remain in the office of the survey for reference. Sections.

In the field work, and likewise in the preparation of the maps, &c., I have been ably assisted, as on previous occasions, by Mr. Hugh Fletcher. In addition to the gentlemen mentioned in former reports, to whom I am indebted for incidental assistance and valuable information, I have Acknowledgment of aid.

pleasure in naming Mr. Patrick Neville, underground manager of the International Company's colliery at Bridgeport, to whom I believe is due the merit of having first recognized and pointed out the subdivision of the Sydney coal field into several subordinate basins; also Mr. Hugh E. Ross, of Margarie; Mr. William Rumble, Superintendent of the Cape Breton Company's works; Mr. Henry Mitchell, of Little Glace Bay; Mr. William McQueen, of Block House colliery; Mr. Alexander Henderson, of North Sydney; Hon. Charles Campbell, of Baddeck; Mr. William Campbell, of Cow Bay; Mr. James Baird, of South Head; and Mr. Cossitt, of Sydney. I have also specially to acknowledge a continuance of favors from Albert J. Hill, Esq., C. E., in procuring and presenting fossil specimens, and copies of valuable plans, &c.

The compass bearings in this report are given with reference to the true meridian, the variation being 26° west.

GENERAL DESCRIPTION.

Area. The carboniferous rocks which form the subject of the following remarks, occupy an area which may be described as a parallelogram, thirty-two miles long by thirteen miles wide, bounded on the north, east and west by the Atlantic ocean, and on the south by the underlying rocks of the interior of the island. The longer axis lies in a direction W. 22° N. and E. 22° S.

Structure. The rocks of this district are affected by three anticlinal and four synclinal folds, approximately parallel to one another, the latter named respectively the Cow Bay, Glace Bay, Sydney Harbor and Bras d'Or basins.

The several folds are marked by the occurrence of bays and channels running in a direction nearly parallel to their axes, forming deep indentations in the coast, and in some instances affording excellent harbors. The subdivisions above specified are thus geographically, as well as geologically, well marked; and it is worthy of notice, in this connection, that these bays and inlets, and the valleys which form their continuation inland, appear to owe their origin to the folding and consequent weakening of the strata, which may have first determined the direction of the drainage; a direction which it has, in a general way, retained throughout all subsequent changes.

Before entering upon the consideration of the several subordinate basins, and of the disturbances which have affected the Coal Measures, I shall give a general description of the various strata of which these measures are composed, referring in illustration to the sheet and table of grouped sections.

In the area to which this report refers, the rocks fall into three classes. These are in ascending order :—

Three divisions.

I. Carboniferous Limestone.
II. Millstone Grit.
III. Coal Measures.

I.—The Carboniferous Limestone.

As this division is only developed at a few points in the area explored, I have little to add to the general remarks respecting it already made in the Report for 1873-74, pages 172 to 174. Reference is there made to three localities where these rocks are displayed, namely: Point Edward, and the shores around the head of Sydney Harbor, the peninsula on which the town of Sydney stands, and Kelly Cove.

Sections of the Carboniferous Limestone.

Referring to the general notice of the rocks of this formation in last year's report, I shall now give a few sections, measured in descending order at each of the above-named places. These sections comprise the upper beds of the Carboniferous Limestone.

The first section forms the continuation of that of the Millstone Grit, given at page 185; it commences on the shore, a little above the South Bar in Sydney Harbor, where the carboniferous limestone and millstone grit formations meet; the former thence skirting the shore for a great distance southward.

SECTION I.

SYDNEY HARBOR.—SOUTH BAR TO SYDNEY.

Dip North 64° *East*, < 8°.

	FEET.	IN.
Red and grey marl, with intercalated masses of sandstone.......	4	0
Greenish and dark blue sandstone; red grains and scales of mica sparingly diffused: in part conglomerate, made up of the materials of rocks immediately underlying	3	0
Red and grey marl..	2	0
Greenish-grey fine-grained sandstone, passing into red and grey marl...	1	0
Red and grey marl..	16	0
Red and grey coherent marl: contains grains of quartz and becomes mottled, greenish, and red coarse sandstone, or calcareous conglomerate. In some places coherent, green, coarse sandstone in lenticular masses..	2	0

		FEET.	IN.
	Grey, flaggy, fine-grained micaceous sandstone, coarse at top; becomes mottled red and green, micaceous, friable sandstone, with yellowish blotches. Three feet at the top becomes a conglomerate and quartzite in six layers, the top layer holding traces of variegated copper ore, red calcspar and gypsum..........	6	0
Hematite.	Hard grey siliceous sandstone or quartzite, constituting sometimes a jasper by being colored red with hematite in blotches. Occasionally a fair hematite ore, with over 30 per cent. of metallic iron. Attempts were made to work this ore (which is that referred to in Report for 1873-74, page 176), but failed, owing to irregularity in quality and in distribution among the red marl. Passes apparently into a reddish sandstone........	2	0
	Red marl, with nodules of soft white argillaceous limestone, varying in size from one-eighth of an inch to six inches..........	34	0
	Measures concealed; probably red marl and sandstone..........	30	0
	Light blue or cream-colored compact limestone.................	1	0
	Measures concealed....................................	30	8
	Reddish-grey, fine-grained, calcareo-micaceous sandstone, regularly jointed five feet apart; joints running N.W. and S.E.........	4	6
	Red marl..	5	6
	Reddish, fine-grained, micaceous, slightly calcareous sandstone...	0	6
	Mottled red and green marl..............................	6	6
	Reddish, fine-grained, micaceous sandstone..................	0	6
	Mottled red and green marl..............................	5	8
	Reddish-grey, fine-grained, micaceous, slightly calcareous sandstone	5	0
	Measures concealed; probably red and green marl and sandstone.	340	0
	(Here the line of section is transferred to Sydney Point, running thence to the town of Sydney, the section being well exposed. Dip N. 54°, E. < 10°).		
	Grey, fine-grained sandstone, tinged slightly red................	30	0
	Measures concealed.....................................	167	0
	Red and green marl......................................	8	0
	Red, micaceous, fine-grained sandstone......................	2	0
	Red and green marl......................................	6	0
	Grey sandstone	1	0
	Red and green marl......................................	3	0
	Soft crumbling limestone..................................	2	0
	Red and green marl......................................	2	0
	Hard, red, micaceous sandstone, slightly calcareous; much lime in joints	0	6
	Thin-bedded, red, micaceous sandstone	8	0
	Soft, black, fetid limestone, showing reticulations of calcspar on weathered surfaces; shells.................................	2	0
	Nodular limestone, with *Stigmaria*..........................	2	6
	Slightly calcareous, greenish-grey, micaceous sandstone..........	7	0
Fossils.	*a* Bituminous shale, highly calcareous, with *Sigillaria*, *Lepidoden-*		

	FEET.	IN.	
dron, and other plant impressions; also coprolites, fish scales, teeth and spines, and *Naiadites*	3	6	Fossils.
Argillaceous underclay, with *Stigmaria*	0	10	
Nodular limestone	0	6	
Alternations of red and green marl, sandstone and limestone	28	8	
Alternations of dark-grey, argillaceous shale and limestone; the latter in thin beds	15	5	
Light-green, laminated, calcareous sandstone, with red streaks; ripple-marked	3	0	
Green and red marl	4	0	
Green and red calcareous sandstone	1	10	
Bright red shale, with thin irregular limestone nodules	4	0	
Nodular limestone	0	6	
Red and green marl	4	6	
Hard limestone	0	4	
Alternations of red and green marl, red sandstone and arenaceous shale	27	8	
Mottled nodular limestone	0	9	
Red marl, with calcareous nodules	6	0	
Red and green sandstone, highly micaceous	2	4	
Limestone and red marl in thin bands	2	4	
Massive limestone	0	6	
Laminated red and grey marl	1	0	
Greenish, fine-grained limestone and marl, in irregular bands	3	0	
Massive limestone	1	2	
Calcareo-arenaceous shale	1	4	
Red and green marl	3	0	
Compact bluish limestone	0	10	
Grey arenaceous and micaceous shale	4	0	
Green marl	3	0	
Red marl	6	0	
Brown marl, with thin red and green layers, more or less compact, but sometimes laminated	6	0	
Compact green marl	0	9	
Red marl	1	0	
Green marl	0	6	
Grey nodular limestone	0	6	
Total thickness	879	7	

Fault.

The above section terminates about the middle of the peninsula on which the town of Sydney stands; thence southward the measures are concealed, probably in part from the disturbance of the strata caused by the fault which comes out on the harbor at the mouth of Freshwater or Wentworth Creek. The space between this point and the base of the section is occupied by large loose blocks of millstone-grit sandstone in great profusion.

In this section fossils were found principally in the three and a half feet bed (*a*) of calcareo-bituminous shale, near Sydney Point, which is copiously charged with both plant and animal remains, the latter of a brackish water type.

Limestone Creek section.

The section from Limestone Creek, on the north-west arm of Sydney Harbor, being similar to the above, and, like it, incomplete, it is scarcely necessary to give it here. The chief difference consists in the occurrence of a bed of gypsum, five feet thick, about 350 feet from the summit of the section. Some of the limestones contain small portions of inspissated bitumen.

Point Edward section.

The next section, which is taken on the west side of the anticlinal, running out at Point Edward, and on a line bearing S. 45° W. from that Point to Morrison Brook, where the older rocks appear, (Report for 1873-74, p. 173,) probably comprises the entire volume of the lower carboniferous formation in this district. The thicknesses given of the strata, in some parts of the section, are only approximate; but it may, on the whole, be regarded as tolerably complete.

SECTION II.

LOWER CARBONIFEROUS ROCKS,—POINT EDWARD, SYDNEY HARBOR, TO MORRISON BROOK.

Dip varies as specified in the Section.

	FEET.	IN.
Large blocks of millstone grit sandstone, on crown of anticlinal at Point Edward, probably in place........................	—	—
Sandstone and marl..	6	0
Laminated red sandstone, with green blotches; large nodules of iron pyrites; *Sigillaria* and other plant impressions.........	4	0
Compact yellowish sandstone..............................	7	0
Friable, micaceo-arenaceous limestone	2	0
Red and green marl..	13	9
Compact limestone, one inch; nodular limestone, six inches	0	7
Soft red marl	15	2
Red and green sandstone	16	4
Calcareo-bituminous shale, as at Sydney Point, (*a*.) with fish teeth, scales, spines and coprolites; also *Sigillaria*, *Lepidodendron*, &c.	3	0
Limestone, in part black, crystalline: siliceous geodes, in thin concentric agate-like layers................................	4	0
Variegated red and green micaceous sandstone..................	10	8
Red marl, with red and green nodular limestone bands...........	32	10
Red, ripple-marked, micaceous, shaly sandstone	0	10
Red and green marl, with thin limestone bands..................	10	6

	FEET.	IN.	
Red and green limestone; a compact bed	3	0	
Red and green marl. Dip N. 56° E., < 6° 20′	22	10	
Bluish-grey shaly sandstone	2	0	
Red and green compact sandstone	2	0	
Measures concealed, probably all blue marl, or soft argillaceous rock	6	10	
Bluish-grey micaceous sandstone	4	0	
Measures concealed—great profusion of limestone blocks on beach. Dip N. 32° E., < 7°	30	0	
Blue limestone	1	6	
Red and green marl, with nodular and compact limestone in alternating beds	22	2	
Compact sandstone; a conspicuous bed—ripple-marked surfaces	0	10	
Mixed sandstone and marl	8	11	
Limestone	2	0	
Red and green marl	8	0	
Measures concealed; many blocks of limestone and calcareous conglomerate strewn on the beach. Dip N. 9° E., < 8°	79	0	
Measures concealed to Dixon Point. Dip N. 9° E., < 10°	380	0	
Compact grey limestone; thickness undetermined; probably about	40	0	
Red and green marl, and sandstone (not well seen). Dip N. 35° E., < 13°	88	0	
Fine-grained, greenish, calcareous sandstone	5	0	
Measures concealed	433	0	
Fine-grained greyish sandstone; indefinite	48	0	
Greenish, impure, arenaceous limestone	4	0	
Coarse red and green sandstone. Thickness probably about	10	0	
Measures concealed. Dip N. 9° E., < 14°	64	0	
Black bituminous limestone, with red patches; a little galena	2	0	
Measures concealed	48	0	
Limestone; thickness indefinite; probably about	9	0	
Measures concealed	119	0	
COAL reported to occur in a brook on the land of Joseph Rudderham; exact position and description unknown; said by Neville to be from two to four inches thick—say	0	3	
Measures concealed	212	0	
Red marl, from which bricks were made many years ago	10	0	
Measures concealed	38	0	
Compact bluish-grey limestone; some of the beds charged with *brachiopods*, *encrinites*, &c.; said to have been quarried many years ago, to burn lime for the building of Louisburg; the quarries still to be seen	45	0	Fossils.
Grey, thin-bedded, calcareous sandstone	5	0	
Greenish limestone, with small portions of galena. Dip N. 6° E., < 15°	2	0	
Red and green calcareous shale and marl	70	0	

	FEET.	IN.
Grey compact limestone, quarried for lime-burning: forms the reef called Limestone Point	7	0
Red calcareous sandstone	5	6
Red marl	39	0
Thin, laminated, calcareous beds	6	0
Alternations of red and green marl, and greenish limestone	6	6
Measures concealed; reddish conglomerate debris on beach	400	0
Fine-grained reddish conglomerate	24	0
Measures concealed; but consist of conglomerate, marl and limestone. Dip N. 1° E., < 16°	370	0
Red and green marl, and purple conglomerate (Watson Brook)	10	0
Measures concealed	160	0
Thick-bedded, compact, dark grey limestone; a little purple copper ore and galena; quarried for lime-burning. Dip N. 6° W., < 17°	32	0
Measures concealed	500	0
Greenish arenaceous limestone, at mouth of Ball Creek	3	0
Fine-grained reddish conglomerate, at mouth of Ball Creek	6	0
Measures concealed	286	0
Sandstone and arenaceous shale at Grantmire Brook mill-dam	10	0
Red and green marl; not well seen; probably about	10	0
Arenaceous shale and thin-bedded sandstone, overlaid by bluish-grey sandstone	8	0
Red marl, &c., to mill-dam	281	10
Pebbly limestone-breccia of Grantmire Brook. Dip N. 16° E., < 17°	175	0
Measures concealed; estimated thickness to the older rocks of Morrison Brook. Dip N. 26° W., < 17°	300	0
Total thickness of Lower Carboniferous rocks	4,591	10

II.—The Millstone Grit.

Previous descriptions

The rocks comprised under this division are developed throughout their entire thickness within the limits of the area explored, and have been briefly described in a previous report (1873-74, p. 176.) An approximate estimate was given of the thickness at Sydney Harbor. Further examination has confirmed the general accuracy of these remarks, and has also afforded the means of describing in greater detail this most important member of the carboniferous series.

The description given of this formation in the last annual report, as consisting of an almost unbroken series of beds of coarse grey sandstone, with occasional irregular patches of argillaceous shale and coal, was based upon observations in the middle and western end of the field. Subsequent examinations in the eastern section, where the same formation is very extensively developed, render some important modifications of the previous description necessary. There the entire formation is much thicker; and while still preserving the same general character and the same relations to the overlying and underlying rocks, affords evidence of local subsidence and of deposition in deeper water and under more quiescent conditions; with thicker and more regular beds of argillaceous shale, and seams of coal, one of which, at least, is of workable dimensions and quality.

There can be no doubt that the materials of which the millstone grit rocks are composed, have been derived chiefly from the disintegration of the rocks underlying, which may have been either the lower carboniferous sandstones, shales and conglomerates, or the older crystalline rocks from which these have in their turn been derived. This fact is very strikingly manifested on the shores of the Great Bras d'Or, where some beds of the Millstone Grit are found to be largely composed of angular fragments of red orthoclase from the syenite of St. Anne's Mountain in the immediate vicinity, mixed with rounded quartz pebbles; while at other places, more remote from such crystalline masses, the ingredients consist entirely of the comminuted fragments of such rocks as have been described as entering into the composition of the lower carboniferous formations. This fact may probably account for the marked predominance of red shale and sandstone in the Millstone Grit of the Mira Bay section, which in this respect is more closely allied than in the western district to the typical series of rocks of this division in the Joggins section, as described by Sir William Logan, from which, however, it differs in the general absence of calcareous beds.

Section at Mira Bay.

The section above adverted to, which is afforded by the cliffs at the western side of Mira Bay, where they rise in some places to the height of 140 feet above the sea, is a remarkably perfect one; and is, in fact, the only detailed section of this formation which could be obtained by direct measurement, or with any degree of accuracy. The following is an abstract of the details in descending order, commencing at a point where it is believed the Millstone Grit gives place to the Coal Measures. This section extends over a length of ten miles.

SECTION III.

MILLSTONE GRIT FROM SOUTH HEAD TO HEAD OF MIRA BAY.

Dip North 12° *East;* ∠ 5° 31′ (*average*).

	FEET.	IN.
Red and green argillaceous shale, red areno-argillaceous shale and red sandstone, in alternating beds, sometimes passing into each other, one bed holding large *Stigmaria*	80	9
Greenish-grey sandstone and arenaceous shale.........	24	9
Red and green rocks, as above.	13	0
Grey argillaceous shale............................	1	6
Carbonaceous shale, with *Cordaites* and clay	0	6
Underclay, with ironstone nodules...................	2	9
Red and green argillaceous shale, sometimes in alternating beds, and sometimes mottled..............	31	6
Greenish-grey sandstone and arenaceous shale	24	3
Nut-conglomerate, with occasional larger pebbles; drift trees converted into spathic iron	10	0
Carbonaceous shale, with *Cordaites;* but only local....	0	3
Argillaceous shale and clay; upper part holding *Stigmaria* where the carbonaceous shale is present.....	9	0
Greenish-grey sandstone in alternating massive and flaggy beds.................................	19	6
Red and green shale and sandstone in alternating beds.	38	0
Carbonaceous shale............................	0	0½
Clay...	0	4
Carbonaceous shale............................	0	0½
Greenish sandstone, with *Stigmaria*..................	2	0
Greenish sandstone, with thin layers of shale; many plants	13	0
Greenish-grey argillaceous and arenaceous shale; many plants	31	8
Grey sandstone and conglomerate irregularly mixed: large trees converted into black crystalline carbonate of iron; many drift plants and a little coaly matter. Conglomerate, coarse: pebbles composed principally of quartz, with chlorite, reddish and green feldspar, blue, green and grey slaty rocks, and mica slate..................................	15	0
Red and green sandstone and shale..................	31	8
Grey sandstone and conglomerate, sometimes red: plants	67	6
a Red and green sandstone and argillaceous shale; sometimes passing abruptly on the strike into grey.	185	9
Grey argillaceous shale, with erect trees, and many plant impressions	8	5

	FEET.	IN.	FEET.	IN.
Red and green argillaceous shale			30	0
Red, fine-grained sandstone; many fucoids			15	0
Grey sandstone and argillaceous shale, mixed			37	9
Alternations of rock, similar to the above for a great distance, including another coarse conglomerate bed, with large trees, wholly converted into spathic iron. All the beds intermix and replace each other, none preserving the same appearance for any great distance			748	9
Coal Brook Seam:				
Coal	0	3		
Clay	0	6		
Coal	0	9		
			1	6
Underclay			5	0
Carbonaceous shale			0	1
Underclay			1	6
Red and green sandstone and shale; frequently replacing and replaced by grey rocks of similar character			151	3
Carbonaceous shale, with *Cordaites*			1	6
Underclay			1	1
Carbonaceous shale, with *Cordaites*			0	10
Grey argillaceous underclay and shale			10	0
Reddish arenaceous shale			9	6
Carbonaceous shale			0	0½
Argillaceous shale, with sandstone in variable masses; *Stigmaria* at top			3	10
Coal, carbonaceous shale and clay			1	2
Underclay			2	8
Grey argillaceous shale			11	0
Grey massive and laminated sandstone, replaced in part by red shale			21	0
Greenish argillaceous shale, with *Cyclopteris*, *Pecopteris*, *Sphenopteris*, *Cordaites*, top tufts of *Lepidodendron*, &c.			3	0
Coal.				
Coal, with much interlaminated pyrites and mineral charcoal	0	8		
Coal and clay	0	2		
			0	10
Underclay			2	0
Grey argillaceous shale and sandstone; many plant impressions and *Stigmaria*			36	0
Red and green sandstone and shale			17	6
Coal and carbonaceous shale			0	10
Grey, argillaceous underclay, with ironstone nodules			3	0

	FEET.	IN.	FEET.	IN.
Red and green argillaceous and arenaceous shale and sandstone			72	2
Grey sandstone and shale; some beds containing *Stigmaria*, and others both erect and prostrate *Sigillaria*.			54	4
COAL.				
Coal	0	0½		
Carbonaceous shale	0	3		
Coal	0	0½		
			0	4
Argillaceous shale, with ironstone in layers			3	0
COAL and carbonaceous shale (*Cordaites*)			1	6
Argillaceous shale			5	6
TRACY SEAM.				
Coal	3	1¼		
Clay	0	5¼		
Coal	0	7		
			4	1½
Underclay			5	0
Grey sandstone and shale, with plant impressions			15	6
Carbonaceous shale			0	3
Clay			0	8
Argillaceous shale			0	4
Grey shale and sandstone, with irregular patches of coal; much ironstone			30	11
COAL			0	2
Carbonaceous shale			0	9
Argillaceous shale			2	3
Grey sandstone and shale; occasionally reddish; *Stigmaria*, streaks of coaly matter and carbonized plants			248	1
Measures concealed by False Bay Beach			329	6
Coarse and fine-grained grey sandstone, in alternating beds			98	0
Grey, argillaceous shale, with erect trees			4	0
COAL.				
Coal	0	3		
Clay (*Stigmaria*)	0	9		
Coal and carbonaceous shale	0	9		
			1	9
Underclay, with streaks of coal			3	0
Grey, or greenish-grey, argillaceous shale			37	6
Grey sandstone—coarse and fine-grained			289	0
COAL.				
Coal, (3 to 6 inches)	0	4		
Carbonaceous shale	0	2		
			0	6
Underclay, with *Stigmaria*			3	0

	FEET.	IN.
Sandstone and argillaceous shale, irregularly mixed....	9	0
COAL—one foot six inches to two feet (not well seen)...	1	9
Underclay; argillaceous, with *Stigmaria*..............	4	0
Grey sandstone; coarse and fine beds alternating; a few irregular beds of argillaceous shale; streaks of coal; carbonized drift plants; lenticular bed of red shale, ten to fifteen feet............................	126	0
Measures concealed................................	37	0
Coarse grey sandstone.............................	31	0
ROUND ISLAND SEAM.		
Coal, not well seen, said to be	2	0
Fine-grained sandstone, with plants	43	0
Strata, consisting where seen of grey, coarse and fine-grained sandstone; not exposed along the shore of Mira Bay, except at the gut, or mouth of Mira River. Blocks of grey sandstone are strewn along the beach, as far south as McKeagan Point, where red marl, limestone, and calcareous sandstone—all characteristic of the carboniferous limestone formation—are met with. On the banks of Mira River, as far up as the railway bridge, grey sandstone appears, forming cliffs twenty to fifty feet high. Thickness undetermined; probably from 2,000 to 3,000 feet ..	2,500	0
Total thickness of Millstone Grit................	5,706	8

Southern limit of the Millstone Grit.

So far as at present known, the southern limit of the Millstone Grit is reached at the point designated as the base of the above section. The Round Island seam is the lowest yet discovered in this district; and from all that is known of it, is probably quite worthless for mining purposes, as, although said to have shown a thickness of two feet at the sea beach, the exposure I saw there, is not nearly that thickness, and a short distance inland, it had considerably diminished.

It is to be observed from the above section, that although there is a great preponderance of the characteristic grey, false-bedded sandstone of the Millstone Grit, charged with the remains of drifted plants, there is at the same time a large development of beds of argillaceous shale, both red and grey, the latter in many instances copiously charged with vegetable remains in a good state of preservation, and in some cases with erect trees. There are also some seams of coal, which will be again referred to.

The above section gives the strongest confirmation to the opinion advanced in my previous report, (1873–74, p. 177) that all the coal seams in this part of the measures underlie at a considerable depth those in the Sydney section, and belong to the Millstone Grit.

Changes in the character of the beds.

Another striking peculiarity exhibited in this section consists in the changes undergone in many instances by the same beds, both in color, and in essential mineral characteristics. A stratum consisting at one place of coarse grey sandstone is frequently found, when followed to no great distance, either on the strike or to the dip, to be replaced by red sandstone, or by red or grey argillaceous shale. Such replacements are occasionally observed in the beds of the Coal Measures, but not to the same extent, or in such a striking manner, as in the section now under review. The trunks and roots of prostrate trees are, in these beds, sometimes found converted into black crystalline carbonate of iron. No beds of limestone were observed in the Mira Bay section, and carbonaceous shales are extremely rare, and when found, consist of very thin beds, composed almost entirely of the matted and pyritized leaves of *Cordaites*. This characteristic appears also, more or less, to pertain to most of the coal seams which occur.

Fossil plants.

The fossil plants in these beds, although by no means rare, are not in such profusion or variety as in the Coal Measures. In the latter it has been observed by Mr. Richard Brown, in describing the Sydney Mines section, that "it is a singular fact that not even the trace of a fossil plant, nor any organic substance has been found in any of the red shales, although they have been carefully examined for that purpose."* In rare instances I have detected obscure traces of vegetation in such beds, even in the Coal Measures; but in those now under notice, they are quite frequent.

Fossil plants in the Mira Bay section.

The fossil plants observed by me in the Mira Bay section are of the following genera, which, however, do not probably include the entire flora of these measures: *Cordaites, Neuropteris, Cyclopteris, Pecopteris, Sphenopteris, Alethopteris, Stigmaria, Sigillaria, Lepidodendron, Calamites*. The species have not yet been determined. Fucoids are also of frequent occurrence, and ripple-marked sandstones are not wanting. No remains of bivalves, crustaceans or fishes were observed in any of these beds; although the latter have already been described as occurring in one of the shale beds of the Millstone Grit on the shores of Sydney Harbor. (Report of Progress, 1873-74, p. 176.)

Thickness of the Millstone Grit.

The total thickness of the Millstone Grit on Mira Bay, as will be observed by the section, is 5,707 feet. The thickness (5,972 feet) assigned by Dr. Dawson* to the same series at the Joggins—based upon Sir William Logan's measurements, and comprising the sum of Sir William's Divisions 5, 6 and 7,—corresponds very nearly with this; and it may be remarked that, with the exception of the occurrence of some calcareous beds at the Joggins, and the comparative thinness of the coal seams there, the general resemblance of the sections is very striking.

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* Quarterly Journal of the Geological Society of London, vol. vi., p. 128,

Section North Head of Cow Bay.

At the North Head of Cow Bay, the millstone grit rocks are partially exposed, being brought to the surface by an anticlinal. They form bold cliffs, rising perpendicularly to the height of upwards of 100 feet above the sea. The upper beds of the formation only are exposed; and section IV. which is in continuation of that of the productive measures of the Glace Bay basin (page 213) is interesting, as exhibiting some striking features of similarity to that at South Head; commencing like the latter at a point where the grey strata of the productive measures give place to the red, purple and green shales and sandstones which characterize the Millstone Grit in the eastern part of the field.

SECTION IV.

MILLSTONE GRIT.—NORTH HEAD, COW BAY.

Dip North 5° to 10° West, ∠ 5° *to* 35°

	FEET.	IN.	FEET.	IN.
Mottled, red and green, argillaceous shale..............			12	0
Bluish-grey, coarse sandstone			14	0
Purple, shaly sandstone, with seams of calcspar			6	10
Red and green sandstone, argillaceous and arenaceous shale, in alternating beds			111	2
Carbonaceous shale with *Cordaites*, lenticular masses of limestone..			0	3
Grey and red argillaceous underclay..................			5	0
Grey and red argillaceous shale......................			9	1
COAL.				
Carbonaceous shale.........................	0	5		
Carbonaceous underclay...	0	5		
Coal and carbonaceous shale.....................	0	1½		
			0	11½
Crumbling, argillaceous underclay......................			3	6
Grey, argillaceous rock, weathering white.............			7	0
Greenish-grey sandstone, ...			10	0
Bluish, argillaceous shale..........................			5	0

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* Acadian Geology, 1868. pp. 176-178.

	FEET.	IN.	FEET.	IN.
Carbonaceous shale with *Cordaites*			1	6
Grey arenaceous shale			5	0
Carbonaceous shale			0	1
Underclay			2	0
Grey and greenish argillaceous and arenaceous shale			22	0
Greenish-grey sandstone			5	0
Bluish argillaceous shale ; lower part carbonaceous, and charged with *Asterophyllites*, *Neuropteris*, *Cordaites*, &c.			3	0
COAL.				
Coal	0	2½		
Clay and carbonaceous shale	0	3		
Coal	0	2		
Clay and carbonaceous shale	0	1½		
Coal	0	1½		
			0	10½
Underclay, coherent, arenaceous			3	4
Greenish-grey compact sandstone			3	0
Red and grey argillaceous shale			3	0
Grey arenaceous shale : becomes sandstone ; carbonized drifted plants			9	0
Red and green, crumbling, argillaceous rock			16	0
Blue and reddish sandstone and arenaceous shale			10	0
Greenish-grey, laminated sandstone ; sometimes conglomerate, with nodules and layers of ironstone: strong chalybeate springs			20	0
Dark blue, arenaceous shale			13	6
COAL.				
Carbonaceous shale	0	1		
Grey, argillaceous shale	0	4		
Coal	0	2½		
			0	7½
Underclay, coherent, arenaceous			1	6
Red and green argillaceous and arenaceous shale			5	9
Grey, thick-bedded sandstone			11	0
Grey arenaceous shale			5	0
Carbonaceous shale			0	1½
Underclay			2	0
Reddish, arenaceous shale			5	6
Bluish and green, argillaceous shale, with numerous black bands			6	0
Grey crumbling argillaceous shale, with *Stigmaria*			3	0
Reddish argillaceous rock (*marl*)			2	0
Grey, shaly and massive sandstone, reddish towards base			11	0
Reddish-grey arenaceous shale, sometimes with green bands			8	6
Red and green argillaceous shale, with *Stigmaria*. A tree rooted in this bed rises into the overlying shale.			8	0

	FEET.	IN.
Red and green arenaceous shale	3	0
Bluish argillaceous shale	3	0
Carbonaceous shale	0	4
Red and green, argillo-arenaceous shale in two beds (*Stigmaria*)	4	0
Red and green sandstone and shale, in alternating beds of various thickness	43	3
Bluish-grey, close-grained sandstone	11	0
Undulating, areno-argillaceous flaggy bed, in a basin of sandstone, the upper surface of which is finely ripple-marked; thins out	2	0
Strong grey sandstone, both flaggy and thick-bedded; many carbonized drift plants; patches and thin beds of conglomerate, with pebbles about the size of a pea	98	7
Total thickness	537	7

The massive sandstone at the base of this section, which is a very conspicuous feature in the physical geography of the district, constituting a high ridge, extending far inland and capped with a profusion of large loose blocks, crops out on the crown of the anticlinal, and forms the extreme point or *bill* of the Head. It probably corresponds with the bed marked (*a*) in the Mira Bay section, (see page 176).

Millstone Grit at Cape Dauphin.

In proceeding westward from this point, the millstone grit rocks are nowhere found on the open Atlantic coast until reaching Cape Dauphin, at the extreme western end of the great carboniferous basin. Here they also constitute a very prominent feature, and are distinguished by the occurrence of the great outlying masses forming the Bird Islands, which occupy the corresponding position to the Flint Islands, off the entrance of Cow Bay; the latter being probably on the continuation of the massive sandstone bed referred to.

The extensive tract of country situated between Mira Bay and Sydney Harbor (with the exception of the Cow Bay basin, and the comparatively narrow fringe of productive measures bordering on the ocean) is underlaid by Millstone Grit; the southern limit of which has not yet been ascertained, except at the extreme points specified. It is probable that its thickness nowhere exceeds that established by the sections at Mira Bay and Sydney Harbor respectively. (See pages 176 and 185.)

West of Sydney Harbor the southern limits of the Millstone Grit have not yet been accurately traced, but there seems little doubt that it becomes gradually thinner in approaching the western extremity of the field. Along the shores of the harbor, as will be seen by the section, Boulardrie Island and Kelly Cove.

the thickness is between 4,000 and 5,000 feet; while on the west side of Boulardrie Island it does not probably exceed 2,000 feet; and at Kelly Cove, where not affected by the fault, 1,800 feet.

The red rocks so largely developed in the Mira Bay section, appear to be for the most part confined to the eastern part of the field. With the exception of a very limited thickness on the shores of Sydney Harbor (marked (*b*) in the section), and at the Little and Great Bras d'Or, no such rocks were observed westward of a point about eight miles east of the town of Sydney.

Faults at Sydney Harbor.—It has been stated in a previous report, (1873-74, page 172), that the disturbances observed around the shores of Sydney Harbor, as indicated by the distribution of the carboniferous limestone rocks, and by the attitude of the coal seams and accompanying strata on either side of the bay, had not been traced to any faults or breaks in the continuity of the strata. Further investigations have confirmed this.

Fault at Freshwater Creek.

At Freshwater Creek, however, south of Sydney, the Carboniferous Limestone comes against the Millstone Grit, by a fault which runs up Maloney Brook, and, keeping south of the Cow Bay road, is seen near the head of Fitzpatrick Lake. Here, it turns more to the south, and has been traced as far as Macpherson road at the bridge over a tributary of Black Brook. Continuing its south-easterly course, it should cross Mira River near the railway bridge, and strike the sea-shore about a mile south of its mouth. The precise amount of displacement is difficult to determine, owing to the imperfect nature of the exposures, and to the want of characteristic bands to mark the respective horizons; but it is a downthrow to the south-west, of probably about 900 feet. The Le Cras seam, opened in several places on the Mira Road, is, most likely, the Fitzpatrick seam repeated by this fault.

From the mouth of Freshwater Creek the fault follows Sydney River as far as Sydney Bridge, where the Carboniferous Limestone is seen on one side of the road, while hills of Millstone Grit rise on the other. It then runs through Forks Lake, towards East Bay; but has not been definitely traced to this distance, and requires further investigation.

Millstone Grit section, Sydney Harbor.

The following are the sections of the Millstone Grit, as exposed on the east and west shores of Sydney Harbor, respectively. The first is in continuation of the section of the productive measures (Section XV.), and connects at the base with that of the Carboniferous Limestone at page 169.

SECTION V.

MILLSTONE GRIT FROM VICTORIA MINES TO SOUTH BAR, SYDNEY HARBOR.

Dip North 18½° *East*, < 16°, *to North* 64° *East*, < 8°.

	FEET.	IN.	FEET.	IN.
Bluish fine-grained sandstone			41	0
Bluish waving micaceo-arenaceous shale			20	0
Grey, brown-weathering, coarse sandstone			30	0
Sandstone and coal irregularly mixed, prostrate trees and large leaf impressions			4	0
Greyish-white underclay, (fireclay)			1	0
Bluish-grey coarse sandstone; sometimes conglomerate, the pebbles consisting chiefly of quartz and red feldspar; patches of argillaceous shale and beds of fine-grained sandstone; streaks of coal; zoned and layered cylindrical sandstone concretions			503	0
Grey argillaceous shale			3	0
COAL.				
Carbonaceous shale, with *Cordaites*	0	7		
Coal	0	1		
			0	8
Underclay			3	0
Arenaceous shale			21	0
Bluish argillaceous shale; many plant impressions			6	9
FRAZER OR MULLINS SEAM.				
Coal, very good	2	0		
Clay	0	4		
Coal, good	4	0		
			6	4
Underclay, argillaceous (fireclay)			0	8
Underclay, arenaceous, with *Stigmaria*, *Sigillaria*, &c.			4	0
Bluish fine-grained sandstone			138	0
Crumbling argillaceous shale			6	0
Grey and bluish, brown-weathering, false-bedded, coarse and fine sandstone			131	0
Bluish argillaceous shale			14	0
Bluish sandstone; carbonized, drift plants			62	0
Bluish argillaceous shale			1	4
Bluish-grey coarse and fine-grained sandstone and arenaceous shale. (Here occurs McPhee Brook, the boundary of G. M. A. property.)			98	0
Sandstone, as before, with patches of argillaceous shale, holding leaves of *Neuropteris*, &c. Carbonized drift plants, *Sigillaria*, *Lepidodendron*, *Cordaites*, &c., in the sandstone			72	0

	FEET.	IN.
Bluish argillaceous shale, with ferns....................	1	0
a. Black bituminous shale, containing *Cordaites* associated with fish teeth, scales, spines and coprolites....	1	0
Argillaceous underclay, with *Stigmaria*................	1	0
Grey and bluish sandstone, as before..................	182	0
Bluish argillaceous shale.............................	8	0
Bluish sandstone; streaks of coal; prostrate trees; no appearance of bedding, but traversed by vertical joints set closely together, and sometimes filled with clay and broken rock; McKay Brook..................	715	0
Sandstone as before described; patches of coal, sometimes in the bedding and sometimes appearing to cross it; many beds or patches of grey argillaceous shale, seldom exceeding six feet in thickness, and for the most part much thinner. In some places the argillaceous shale is replaced by coarse conglomerate.	360	0
Measures concealed, probably sandstone...............	6	0
Sandstone as before. Here occurs the South Bar.......	77	0
Measures seen only at intervals, probably coarse and fine-grained sandstone............................	245	0
Grey false-bedded sandstone..........................	73	0
Measures concealed................................	89	0
Grey sandstone....................................	22	0
Bituminous shale, with fish scales, spines, &c., an irregular bed; similar shale also found in patches in the adjacent sandstone.............................	0	3
Grey sandstone....................................	23	0
Measures concealed	14	0
Grey sandstone, containing a coarse, soft bed, and patches of coal	74	0
Measures concealed for the most part: where seen, consist of grey sandstone, with occasional beds of argillaceous shale (*Neuropteris*)........................	102	0
Greenish-grey, fine-grained sandstone; produces superior flags	10	0
Measures mostly concealed, but probably sandstone.....	105	0
Total thickness of Millstone Grit......	3275	0

Peculiar appearance of the strata.

At the point denoted by the letter (*a*) in the above section, the strata have a very peculiar appearance, which may serve to explain many similar phenomena on a larger scale, in the Millstone Grit. The shale beds appear to occupy a small lenticular basin between two thick beds of sandstone, the upper of which protrudes in places into the shale, which is slickensided at the contact. In one place the basin is nine feet high, and consists of—

	FEET.	IN.
Argillaceous shale	4	0
Carbonaceous shale	1	0
Underclay	4	0

The shales are apparently cut out at the water-level, but at the other end, rise in an attenuated form to the top of the cliff, and are greatly contorted, owing probably to pressure between the sandstone beds. In the sandstone beds there are many erect and prostrate trees, the bark being converted into coal.

The section of the Millstone Grit on the west shore of Sydney Harbor, begins at Stubbart Point, where the productive measures have been assumed to terminate. It connects at the base with the section of the carboniferous limestone rocks at the mouth of Limestone Creek, referred to at page 172.

SECTION VI.

MILLSTONE GRIT. STUBBART POINT TO LIMESTONE CREEK.

Dip, North 27° East $<$ 11° *to North 5° West* $<$ 24°

	FEET.	IN.
Greenish-grey, flaggy, false-bedded sandstone, weathering yellowish-brown; comminuted plants such as *Lepidodendron*, *Cordaites* and *Calamites*	63	0
Greenish arenaceous shale of variable thickness, average	6	0
Yellowish fine-grained sandstone; prostrate trees	100	0
Brown, coarse-grained, almost conglomerate sandstone; pebbles of red and white feldspar, quartz, &c	272	0
Greenish argillaceous shale	2	0
Red marl	3	0
Argillaceous and arenaceous shale	25	5
Blue, wavy, laminated, micaceous sandstone	10	0
Greenish-grey arenaceous shale	5	0
INGRAHAM SEAM:		
Coal	2	0
Measures seen only at intervals; where seen, consist of massive yellow sandstone of coarse and fine grain alternating. Fossil vegetable impressions, rather scantily distributed; patches of coal in fissures of the rock, or appearing as the bark of trees in a fragmentary state, of bright lustre and conchoidal fracture, with much interlaminated pyrites. At one place bright red shale with patches of green arenaceous shale. Thickness estimated from apparent dip, 1st. N. 27° E. $<$ 11°; 2nd. N. 8° E $<$ 13°	2855	0
Grey sandstone, with thin beds of soft, green, argillaceous shale,		

	FEET.	IN.
and irregular streaks of coaly matter ; laminated fine-grained sandstone with patches of coarse conglomerate sandstone.....	150	0
Coarse purple conglomerate, interstratified with thin-bedded sandstone; higher in the cliff it becomes a small coal seam, made up of layers of coal, clay and iron pyrites..................	2	0
Measures concealed..	223	0
Purple, coarse conglomerate, upper part very ferruginous ; also sandstone as before ; Dip N. 5° W < 24°........................	510	0
Total thickness of Millstone Grit................	4228	5

The above section has been, for the most part, constructed by chaining the horizontal distances, and calculating the thickness from the angles of dip taken at different points with the clinometer. This method, however carefully executed, has invariably given me results in excess of those obtained by direct measurement of the several component beds. It is thus probable that the entire volume of the millstone grit formation on the west side of Sydney Harbor may not greatly exceed that on the east side.

Coal Seams in the Millstone Grit.

Coal seams in the Millstone Grit.

Within the limits of the area assigned to the Millstone Grit, in addition to the coal seams exposed in the cliffs at Mira Bay, others have been discovered ; and in some instances considerable sums have been expended in the hope of their proving economically available. Most of the openings, however, have been filled up, and no authentic records of them have been preserved ; but it is to be feared that, in most instances, they have proved unsatisfactory. It was hoped that the knowledge of the facts with regard to these seams would help to determine their probable economic value, and elucidate the general structure of the field. With this view a number of the openings, boreholes, &c., were visited and located : the information obtained, however, although by no means destitute of value, is not so ample or so satisfactory as could be desired.

Round Island seam.

Tracy seam.

Commencing at the eastern part of the field, we find the Mira Bay section to contain about thirteen and a half feet of coal, and to include four seams, which may be said to approach a workable character. Regarding the lowest of these, the Round Island seam, I have already in the notes to the section, recorded all that is known, which certainly is not of an encouraging nature; and this remark is applicable to all the others, except the Tracy seam, which has attracted more attention. It has been mined to a limited extent, and has also been the object of costly but fruitless exploration,* and although out-croppings of coal have been discovered in other and remote parts of the field, which have been supposed to be the continuation of the Tracy seam, the identification has not been conclusively established.

It will be observed by reference to section IV. (page 181) that at the North Head of Cow Bay, there is a thickness of 538 feet of the upper part of the millstone grit formation exposed in the sea cliffs, in which no coal seams exceeding a few inches in thickness occur, the section agreeing as already remarked in this, as in many other respects, with that at Mira Bay. Since the completion of the field work of last season, reports have been received of the recent discovery † of a coal seam upwards of eight feet in thickness, which may be on the strike of this portion of the section, and probably near the base. The seam is said to be, at the crop, eight feet eight inches in thickness, with eighteen inches of very superior coal at the bottom.

Coal seam eight feet thick.

In the vicinity of the Grand Lake road, about six miles north-east of Sydney, a series of small seams have been opened in the Millstone Grit, but in no instance have they been traced continuously, or in such a manner as to establish their regularity or value. The following is an enumeration of these seams, together with the approximate thickness of strata intervening, as ascertained partly by boring and partly by estimate, assuming the dip to be the same as in the productive measures in that district. This section is the continuation downwards of section. (page 218.)

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* Operations at this mine were suspended ten years ago, owing, principally, I am informed, to litigation, but also to the want of a suitable port of shipment. The quality of the coal, according to Professor Lyman, who had an opportunity of examining it when it was worked, is good, half of it very good. At the time of my visit the seam itself was not accessible, but the specimens seen on the bank appeared, to be rather impure, containing much pyrites between the laminæ. Proximate analysis by Mr. R. W. Ells, of the Geological Survey, gave:

Moisture........................	2·235	
Volatile combustible matter....	30·09	(By slow coking 24·83.)
Fixed carbon....................	66·61	Coke swells up and is light and porous.
Ash	0·98	Ash purplish brown.
	99·915	

According to the official returns, the amount of coal yielded by the Tracy mine is 3,000 tons. (See Report of the Commissioner of Mines for Nova Scotia,—Mr. Rutherford's Report,—for 1866.)

† This discovery has been made by Mr. Patrick Neville, of Bridgeport, a very competent and successful explorer in this field, and who has already been mentioned.

SECTION VII.

MILLSTONE GRIT BETWEEN LORWAY AND SYDNEY HARBOR.

Dip, North 64° *East* < 5°.

	FEET.	IN.	FEET.	IN.
COAL.				
Coal	0	3		
Clay	0	9		
Coal and clay	0	9		
			1	9
Strata			41	0
COAL			0	6
Bluish-grey and reddish sandstone and argillaceous shale			130	2
CLARKE SEAM.				
Coal 2′ 9″ – 6″			1	7½
Strata proved by boring; sandstone and shale as above			149	10
COAL " " "			0	7
Strata: lower part green argillaceous shale, with fern impressions			83	1
MARTIN SEAM.				
Coal; good, but withmuch interlaminated pyrites			1	8
Strata; principally grey coarse sandstone			207	0
COAL, coarse pyritous: said to be			2	0
Strata; principally coarse and fine-grained, grey sandstone, estimated on this line of section to the eastern shore of Sydney Harbor			2000	0
Total thickness			2619	2½

Clarke seam.

The Clarke seam may be said to have been proved continuously for a distance of more than two miles, and has been cut both in the International and in the Cape Breton railways. It varies very much in thickness within the limits above specified, and contains a good deal of pyrites. The Martin seam has only been exposed, so far as I could ascertain, at two points, about a mile and a-half apart; namely, on the farm of John Martin, on the Grand Lake road; and on the banks of the South-west Brook, between the International railway and the Bridgeport road.

Martin seam.

About four miles due east from the town of Sydney, on the Cow Bay road, and at the intersection of Fitzpatrick Brook, a seam of coal one foot ten inches in thickness has been opened by a slope sixty feet in length, driven on the dip of the seam N 60° E < 7°. The work was abandoned owing to the smallness and irregularity of the seam, which is probably from 1000 to 1,500 feet of vertical thickness beneath the lowest of those enumerated in section VII.; and from its position in the measures, as well as from various other circumstances, may probably be regarded as the continuation of the Tracy seam.

Le Cras seam.

Three and a-half miles south-east of Sydney, on the Mira or Louisburg road, a seam of coal, varying from two feet to fourteen inches in thickness, has been worked by Mr. Henry Le Cras and others. It has been opened at several points by shallow pits, extending over a length of fifty chains; and by a slope about 60 feet in length on the dip of the seam.

In a borehole, put down to the dip of the slope, the seam is reported to have shown a thickness of two feet nine inches. These works were begun in 1870, with the idea that the proximity of the seam to the town of Sydney might render it available for the supply of that place, but the works were abandoned after having yielded about twenty tons of coal.

Continuation of the Le Cras seam.

A seam, which is supposed on reasonable grounds to be the continuation of the Le Cras seam, is reported to have been opened at the crop, about three miles to the south-east, near the junction of the Morrison and Mira roads. Here also it is said to be two feet thick, and to dip N. 46°E., but has not been mined. Another small seam occurs near this place, which must underlie the former. It is opened at the crossing of Mira road and Black Brook. The thickness could not be ascertained, but is evidently inconsiderable. The coal is an impure cannel, showing fish scales in the laminæ. The Le Cras seam has also, in course of the present year, been found to the north-west of the old pits, by the Messrs. Cossitt, two miles from Sydney, without, so far as I can learn, showing any remarkable difference in size, quality or condition. There are strong grounds for the belief that this seam, although considerably further to the south, may be the same as that at Fitzpatrick Brook, thrown into this position by the Freshwater Creek fault.

At Cossitt's pits, an interesting collection of fossil plants has been made by Mr. Albert J. Hill, C.E., which are thus described by Dr. Dawson:—

"The collection consists principally of leaves preserved in a grey shale, and is remarkable for the fact that it affords three or four species of ferns, with the fructification, which I hope at some future time to figure and describe. The horizon is stated to be that of the Millstone Grit; but, as the subjoined list shows, the plants would not convey that impression, being of species not occurring elsewhere except in the coal formation, and even in the upper part. The following are the species recognized in a cursory inspection of the specimens:

Annularia sphenophylloides. Zenk.

A. longifolia. Brongt.
Sphenophyllum Schlotheimii. Brongt.
S. longifolium?
Calamites cistii. Brongt.
Neuropteris cordata. Brongt.
N. flexuosa. Sternb.
N. auriculata. Brongt.
N. . (New species.)
Pecopteris unita. Brongt.
P. arborescens. Schlot.
Alethopteris Serlii. Brongt.
Sphenopteris. Several species, some of them probably new.
Asterocarpus and other ferns, showing fructification, and not yet described.
Cordaites borassifolia. Unger.
Lepidodendron Sternbergii. L. and H.
L. dispersum. Dn.
Lepidophloios Acadianus. Dn.

"A nearly similar group of plants appears in specimens collected by Mr. Hill at Henderson's pit, near Black Brook, which would seem to be on the same horizon."

In these beds Mr. Hill also detected the remains of several insects. These have been described* by Samuel H. Sçudder, of Cambridge, Mass. They belong to the genera *Libellula* (Dragon-fly) and *Blattina* (Cockroach). No true *Odonata,* to which group the *Libellulinæ* belong, have been before found in strata as old as the Carboniferous.

Mullins or Frazer seam.

On the eastern shore of Sydney Harbor, in the sea cliffs to the south of the Victoria mine, a seam of coal of tolerably good quality and of workable thickness crops out, called the Mullins or Frazer seam. This seam is 840 feet below the point assigned as the upper limit of the Millstone Grit; and is separated from the next overlying seam, which is in the productive measures, by 920 feet of barren sandstone. The Frazer seam, which dips N. 26° E. < 30°, is not less than six feet in thickness, having the following section:

	FEET.	IN.
Coal, very good	2	0
Shale or clay	0	4
Coal	4	0
	6	4

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* "Canadian Naturalist," Vol. viii., No. 2.

It has been opened for a distance of about 100 feet by a level or drift from the sea shore, and the coal extracted for country use. The following is a proximate analysis, by Dr. Dawson, of a sample of coal from the upper bench of this seam :

Analysis of the Frazer coal seam.

Volatile matter	31·4
Fixed carbon	62·4
Ash, dark reddish-grey	6·2
	100·0

"Coke somewhat compact. This coal has some of the properties of cannel. It has great heating power and produces much dense carbonaceous gas, but is inferior in purity to the others."

Owing to the heavy covering of drift and soil, no attempts have been made to trace this seam inland ; but at the distance of four and a half miles eastward, on the northern shore of Lingan or Bridgeport Basin, openings were made by the neighbouring farmers, upwards of twenty years ago, on the crop of a seam called the Carroll, which in all probability, judging from the character of the coal and its position in the measures, is identical with the Frazer seam.

Carroll seam.

The following is the section of the Carroll seam, as reported to me on good authority, the seam itself being concealed at the time of my visit :

	FEET.	IN.
Top coal, soft	1	6
Clay or shale	1	6
Good coal	4	0
	7	0

Another account gives five feet as the thickness of the shale band between the two coals. As the openings extend for a distance of about 500 feet along the crop, that some variation in the thickness of the band should occur is highly probable. The analysis by Dr. Dawson gives :

Analysis of the coal, Carroll seam.

"Volatile matter	32·8
Fixed carbon	61·4
Ash	5·8
	100·0

Coke vesicular, ash red ; coal reported good for blacksmiths' use."

The roof shale, which is highly arenaceous, bears a strong resemblance in color and composition to that overlying the Frazer seam at the

Victoria mine. Should the tract of land lying between Sydney Harbor and Bridgeport Basin, the mining rights of which belong to the General Mining Association, be underlaid, as there seems little reason to doubt, by this seam, retaining the same thickness it has at either extremity, the Association will own, in addition to the many other fine seams on their Lingan tract, an area of 7,290 acres, underlaid by 72,900,000 tons of coal.

Large area of coal.

The Carroll seam reappears near the mouth of the North-west Brook at the head of Lingan Basin, where it is stated to have thinned out greatly; but from want of exposures, this could not be verified. It may be here noted that in this vicinity, at a short distance to the south-west, apparently lower in the measures, and where they appear to have been much broken up, on the crown of an anticlinal, several attempts have been made, in consequence of the occurrence of much coal *debris*, near the surface, to discover a workable seam; but these have hitherto proved ineffectual.

On the western shore of Sydney Harbor, and throughout the whole district to the west of that place, the coal seams in the Millstone Grit are equally, if not more, precarious and uncertain. In the Sydney mines section, page 187, the only seam regarding which any facts could be ascertained is the Ingraham seam, which was opened by a shaft sunk upon it to the depth of twenty feet, in a rising ground near the harbor. At the bottom of the shaft, about two feet of coal, mixed with a little shale, was found. At the distance of sixty feet to the dip from the shaft, it had dwindled down to one foot six inches, mixed coal and clay, and in a bore-hole 300 feet to the dip, only six inches of coal and six feet of clay, with a little coal, were cut. Many unsuccessful attempts have been made at other points to find this seam in workable thickness. Its probable equivalents in other parts of the field, are noted below and on page 238.

With these exceptions, no coal seams were seen in the Millstone Grit in the Sydney mines or Boulardrie districts, and no authentic accounts of the existence of such seams were obtained. At New Campbellton, in the Cape Dauphin district, a seam one foot eight inches thick was discovered by Mr. Alexander Henderson in this formation, underlying the six feet seam about 400 feet, but here also it does not appear to be continuous. This seam is probably the equivalent of the Ingraham seam of the Sydney mines section.

III. The Coal Measures.

Division of the Millstone Grit and Coal Measures.

The boundary line between the Millstone Grit and the so-called productive measures is a somewhat arbitrary one; and by some the distinction may be regarded more as a matter of convenience, for the purpose of description, than as of geological importance. The distinctive mineralogical features are, however, neither few nor trivial; and the separation of the one set of rocks from the other is very important in an economic point of view.

The southern limit of the Coal Measures is very frequently indicated by the occurrence of great angular blocks of coarse sandstone profusely scattered over the surface. Such loose masses are, in all cases, identical in appearance and in mineral character with the sandstone beds of the Millstone Grit, from which they have undoubtedly been derived.

In viewing, at a little distance from the shore, one of the fine natural sections exposed in the sea cliffs, as on Sydney Harbor, towards the point where the millstone grit rocks give place to the productive measures, the distinction is very striking, and speaks to the eye with convincing effect. The uniform and monotonous grey tint of the rugged and uneven coarse sandstones, stretching apparently indefinitely landward is abruptly replaced and relieved by a regular succession of beds of every variety of color in repeated alternations.

I shall proceed to describe *seriatim* each of these distinct classes of strata in the order in which they are enumerated in the large sheets of detailed sections referred to at page 178 in the Report for 1873–74. The whole series corresponds very closely, both in geological position and in composition with division No. 4 of Sir William Logan's Joggins' section. As the measures towards the upper part of the section in the Sydney coal field are cut off by the sea, the entire thickness is nowhere represented; but on comparing the portion exposed with the corresponding portion of the Joggins' Section, it may be inferred that the thickness of the whole,—about 2,500 feet,—is approximately alike in both cases.

Argillaceous shales.

1. *Argillaceous Shale.*—These strata, together with the *Arenaceous Shales* (2), into which they pass by insensible gradations, and the red and green marls (3), from which they differ chiefly in color, and in the general absence of lamination in the marls, constitute upwards of one half of the total thickness of the measures. They no doubt originally consisted of fine mud, with more or less sand intermixed, and are of a grey or bluish-grey color; the darker shade being due to the presence of

carbonized vegetable remains. Some of the beds contain much iron pyrites; and nearly all are charged with argillaceous iron ore, sometimes in thin regular layers, but generally in spherical or ellipsoidal nodules or concretions.

The argillaceous shales, which have obviously been formed in quiet and shallow waters, generally contain a vast variety of fossil plants, chiefly ferns, their most delicate and fragile fronds and stems being beautifully preserved between the laminæ of the shales. Of these the following genera and species in the collection have been determined by Dr Dawson:—*Sigillaria reniformis; S. clathraria; S. eminens; S. Lorwayana (N. S.); Stigmaria ficoides; Calamites cistii; Asterophyllites trinervis; Annularia longifolia; Sphenophyllum (?); Cyclopteris fimbriata; Pinnularia (?); Neuropteris rarinervis; N. flexuosa; N. loshii; N. auriculata; Odontopteris Schlotheimii; Sphenopteris latifolia; Alethopteris Serlii; Pecopteris arborescens; P. cyathea; Lepidodendron; Lepidophyllum (?); Lepidophloios (?); Cordaites borassifolia.**

Fossil plants.

Many trunks of erect and prostrate *Sigillariæ*, and in some cases with their *Stigmaria* roots attached, and growing into the coal seams, are found in the argillaceous shales; and these appear to be confined to no particular horizons. The finding of such fossils in certain sets of strata seems to be due to the accidental circumstance of their having been exposed in the sections at the time the latter were examined, rather than to their non-occurrence in others in which they were apparently absent. The trunks are sometimes of great size, the largest observed being nearly five feet in diameter; the general size, however, is from two to three feet; the bark being converted into coaly matter, and the interior now consisting of sandstone, carbonate of iron, or argillaceous shale. The fluting of the stems is often beautifully preserved, and frequently the scars are visible. A remarkable specimen of a root of one of these trees in a very perfect state of preservation, has been described in the Report for 1873-74, page 179.

Large tree trunks.

Naiadites shale.

Some of the beds of argillaceous shale are very copiously charged with a small bivalve shell of the genus *Naiadites*, associated with plant remains. Such beds are generally of a peculiar greenish-grey color.

The argillaceous shales are not always persistent; but often become arenaceous, and sometimes pass into sandstone. Occasionally, the change is so sudden as to give to the beds the appearance of being

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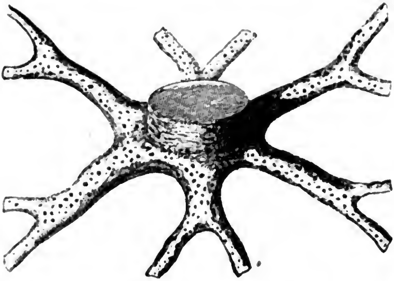
* The above list by no means exhausts the flora observed in these beds, but comprises only such genera and species as are represented by good specimens collected for the museum.

Sigillaria Sydnensis.



Stump and roots of *Sigillaria Sydnensis*, from the roof of the slope at the Emery Mine, Cape Breton. The spreading roots extend from side to side of the slope, which is eleven feet wide.

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faulted. This appearance is, however, due to a local cutting-away of the shales, and a subsequent filling up of the depression by sand.

Red and green marls.

3. *Red and Green Marls.*—The term marl, as applied to the rocks of this class, is not in all cases strictly correct, as they are not always calcareous; but it is convenient as designating a set of strata, having a tendency to disintegrate or be resolved into clay or mud on exposure to the air. Sometimes the grey argillaceous shales partake of this character but only partially and in exceptional cases; while the red and green marls are almost invariably thus distinguished.

Beds of this nature, generally of considerable thickness, are distributed throughout all parts of the carboniferous series. The colors are doubtless due to the presence of iron in different states of oxidation. The prevailing color is chocolate-red or purplish; the green tint occurring more irregularly, sometimes in streaks parallel with the bedding, but more frequently in patches diffused through the red marl, giving to the whole mass a mottled aspect. Occasionally these beds when exposed in a vertical cliff section, show throughout their whole thickness—which in the productive measures is usually from four to eight feet—a ridged and furrowed structure, as if from the effects of lateral pressure. In rare instances, traces of plant impressions and *Naiadites* were found in these beds. They often thin out and entirely disappear, or pass gradually, on their strike, into grey argillaceous or arenaceous shale, and occasionally even into sandstone.

Sandstones.

4. *Sandstones.*—The sandstone beds constitute the most prominent, thickest, and most persistent members of this series of strata. They are very numerous, and are distributed throughout all parts of the formation, generally overlying each coal seam, with an interval of a few feet of argillaceous shale, but sometimes actually forming the roof of the seam. They are probably in part, derived from the disintegration of the beds of the underlying Millstone Grit; from which, they are scarcely distinguishable, except by a somewhat softer texture, and deeper tints of yellowish and greenish hue. They are usually coarse and pebbly, especially towards their base, where, for a limited thickness, they sometimes assume the character of conglomerates. False bedding is very prevalent in the thicker and coarser-grained strata, which are usually of considerable thickness, up to forty or fifty feet. Such beds are generally charged with casts of plants and much carbonized vegetable matter; the presence of which is indicated by the darker color of the layers. The casts are generally too imperfect to determine the species to which the plants belong; but, *Calamites*, *Cordaites*,

Casts of fossil plants.

Lepidodendron, and *Sigillaria*, are obviously the prevailing genera. The conditions point to a period of deposition in troubled waters; the trunks, stems, and leaves having evidently been drifted from a distance, and confusedly mixed together.

Calcareous sandstones.

Many of the sandstone beds in the productive measures are calcareous; and some of the thinner beds highly so. Such calcareous strata are generally flaggy, micaceous, and very evenly bedded; sometimes in extremely thin laminæ, and occasionally ripple-marked; circumstances indicating deposition in shallow and comparatively smooth and tranquil waters. A bed of this description at Lloyd Cove, near Sydney Mines, has furnished, according to Mr. Richard Brown, specimens of the footprints of a land animal; proving that it was deposited in a flat tidal estuary. (See Acadian Geology, page 358.)

Underclays.

5. *Underclays.*—No fact in connection with the measures in this field is more strikingly manifest than the all but invariable occurrence, immediately under each coal seam and bed containing carbonaceous matter, of underclays, copiously charged with *Stigmaria ficoides.* This fact, with reference to the Cumberland coal field in Nova Scotia, and also in South Wales, was long since established by the elaborate researches and explorations of Sir William Logan. The beds designated as underclays are, for the most part, highly aluminous and siliceons, and form good fireclays; they merge by insensible gradations into the beds upon which they rest, and are generally full of ironstone nodules.

The thickness of the underclays varies from a few inches to eight or ten feet. These extremes, however, are very exceptional, and the average thickness may be stated at three or four feet. It is to be remarked that the thickness of the underclays, and their richness in vegetable remains, appears to bear no proportion to the size or purity of the accompanying coal seams.

Stigmariæ.

The roots and innumerable rootlets of *Stigmariæ* constitute the most distinctive feature of these beds. The roots spread themselves horizontally in the beds, and sometimes intertwine. They are often flattened, and converted into sandstone. The rootlets are generally in a carbonized state, and penetrate the beds in all directions, but chiefly downwards. *Stigmariæ* are not wanting in other beds of the Coal Measures, and are found in such conditions as to prove that they occupy the positions in which they originally grew. The Shelly seam (a poor coal, and of small thickness), lying towards the base of the coal measures, rests, however, directly on a six-inch band of fossiliferous limestone, succeeded by a stratum of argillaceous shale. No *Stigmariæ* were observed either in the limestone or in the shale, although in other cases in which limestone forms the floor of a coal seam, these roots are present.

Limestones.

6. *Limestones.*—The Coal Measures in Cape Breton are distinguished by the occurrence of several thin bands of hard, dark-grey, sometimes almost black, fetid or bituminous limestone, generally so rich in organic remains as to appear entirely made up of them, but the presence of which can sometimes be inferred only from the peculiar odor which the rock emits when rubbed or struck.

These limestone beds, of which there are about sixteen, vary in thickness from half-an-inch to two feet; in one instance a bed, of upwards of three feet, was observed; but they do not generally exceed a few inches. They are, on the whole, remarkably persistent throughout the entire field, and thus, taken individually, afford valuable evidence in the identification of the several coal seams at distant intervals. It is to be observed, however, that both towards the eastern and western extremities of the field, they seem to thin out and disappear, while towards the middle they attain their greatest development both in number, in thickness, and in the display of their peculiar characteristics. They are entirely absent in the upper part of the measures, as shown in the tabulated sheet of vertical sections.

Fossils.

The fossils which they contain are identical with those described by Dr. Dawson as occurring under similar conditions at the Joggins (see Acadian Geology, 1868, pages 173 and 181), and are of the following genera: *Naiadites, Cythere, Spirorbis;* with scales, teeth, spines and coprolites of ganoid fishes.* The fish-remains are generally coated with, and sometimes entirely replaced by iron pyrites. In some instances, the limestone shows a well-marked cone-in-cone structure, the cones being at least an inch in diameter.

In grouping for comparison, the various sections which have been measured in this field, (as has been done in the accompanying table) it appears that in all of them, especially those taken towards the middle of the basin, these limestone bands begin and terminate at about the same horizons.

Carbonaceous shales.

7. *Carbonaceous shales.*—Beds of this nature are of very frequent occurrence, interstratified with the argillaceous shales, and may be regarded as coarse coals, intermixed with numerous thin layers of shaly

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* The fish-remains, according to Mr. Richard Brown, belong to the following genera: *Holoptychius; Megalichthys; Paleoniscus; Amblypterus;* and *Gyrolepis.* See Quarterly Journal of the Geological Society of London, Vol. VI., page 132.

matter. Many of the workable coal seams inclose layers or bands of such shale, and also sometimes pyritous bands; which, in proportion to their amount, tend to deteriorate the coal, and necessitate their removal by hand-picking, before it is sent to market. When such a layer occurs, however, near the bottom of a seam, it is of great practical utility for *holing*.

annel coal.

Such beds are sometimes of the nature of cannel, being compact, with conchoidal fracture, containing more or less calcareous matter, and passing into bituminous limestone. In such cases, they are charged with the fossil forms peculiar to these limestones, in some instances, associated with plant remains. More frequently, however, the carbonaceous shales are soft and laminated, and seem to be entirely made up of the matted leaves of *Cordaites*, converted into mineral charcoal. When beds of this nature occur apart from the seams of coal, they are invariably associated, like the latter, with underclays. They are also frequently underlaid by such clays, even when they occur in the coal seams, which are then considered *dirty*. The shale beds are usually very thin, rarely exceeding a few inches; but, as portions of the strata which have been described as argillaceous shale, approximate in character to those now under notice, and as there is an evident gradation between them, it is sometimes difficult to separate them.

In a few instances, the beds of carbonaceous shale are highly calcareous, and are so richly charged with fossils, as to lead to the conviction that these are the source of the lime which they contain. One such bed of calcareo-bituminous shale, observed at Low Point, near the Victoria mine, is a complete mass of the small crustacean *Cythere*. There are also two highly characteristic and very persistent beds of calcareo-bituminous shale, overlying two adjacent coal seams, which serve as a most valuable guide in tracing the structure of the whole field. These beds which, in our sections, we have denominated *Naiadites* shales, appear to be composed entirely of these bivalves, distributed uniformly, and packed closely in layers in the planes of the bedding, giving the shales, when broken, a corrugated appearance.

Coal.

8. *Coal.*—The principal facts in relation to most of the workable seams of coal in Cape Breton have already been amply set forth (Report of Progress 1872–73, pp. 239–295), and a detailed description of the various seams then worked is given in a tabular form at page 291. It should be remarked, however, that the seams there enumerated and described, by no means include all those in this field, but only those of workable quality, above four feet in thickness, which formed actually, at the date

of the report, the object of mining operations. In addition to these, several others of available dimensions and quality, but not then worked, and a great number of smaller seams, are included in the measures. These will be found specified and described, in their appropriate positions, in the various sections herewith presented.

Mode of occurrence of the coal seams.

In taking a general view of the mode of occurrence of the coal seams in this field, it appears that, although local variations are neither few nor small, their similarity of conditions and persistency over great areas is very remarkable. The disturbances which the strata have undergone are not of such a nature or amount as to occasion any great uncertainty in regard to the equivalency of the various seams at different points. In establishing this, however, a great variety of circumstances have to be taken into account, such as the quality of the coal itself, the position and character of the various *partings*, or bands of shaly matter, the mineral and fossil characteristics, and the thickness of the strata between the seams, as well as the manner in which the numerous folds and undulations have affected the general structure.

Remarkable masses of the rock.

In a few instances the coal seams are split by the gradual thickening of their argillaceous partings; but such irregularities, where they occur towards the centre of the basin, do not appear to be very persistent. Sometimes seams, which are of workable thickness and good quality at one place, become, from similar causes, unavailable at no great distance. In one instance,—that of the Block House seam at Cow Bay, and the Victoria seam at Sydney Harbor (which, I believe, are identical),—the continuity of the seam is interrupted at intervals by masses of rock similar to that overlying the coal. These curious rock masses are described as follows by Mr. John Rutherford, M.E., late Inspector of Mines for Nova Scotia, and now Agent for the General Mining Association:—

"Without exhibiting the slightest change in thickness or quality, the coal appears in some cases to terminate, as it were, against a wall of rock. On cutting through this, however, it is again found in its regular position, the planes of the floor and roof being unbroken, and the coal of its usual quality.

"These interruptions—for they are not faults—vary much in thickness; in some instances they are only a few feet thick next the roof, and are thinned down to a wedge-like point near the bottom of the seam; in others they are much thicker, thirty-two feet of stone having been passed through at one place. The wedge shape is a prevailing form, but it is inserted, if I may use the term, in the most irregular and fantastic manner; in some places it is nearly vertical, and in others it is in an oblique position. It is difficult to convey an idea by mere words of the variety of shapes in which these masses are found in the coal. There is generally near the roof a portion of the stone strongly slickensided, which gives it, when found in an angular position with the plane of the roof, the appearance of a fault; but in cutting through it, the coal is found on the other side, undisturbed. Not unfrequently pieces of coal are found imbedded in the stone; and it often happens, when the workman is preparing a hole for blasting, that he chances to drill into some of these, and the operation is much expedited in consequence. I may here state that although, when first met with, the stone is generally so hard as to require the use of powder to remove it, it becomes, in the course of a few weeks, like moistened clay, and may be easily squeezed between the finger and thumb.

"Another and a very striking feature is the detached pieces of stone of the same character as the larger masses. These are generally near the latter, and are in various positions in the coal; sometimes they are near the roof and sometimes close to the floor.

"Such are some of the principal features of these peculiar interruptions in this otherwise evenly deposited and undisturbed seam. How these masses of stone have got into these shapes and positions is a question of some interest; for, although we may readily assume, and with fairness, that the upheaval forming the anticlinal has caused the tilting of the northern edge of the basin, it is not evident how that movement could originate the peculiarities we have described.

"When my attention was first directed to them, I was curious to know whether any parallelism in their courses through the seam could be detected. Of this, however, I do not find sufficiently distinct indications to warrant any deductions from this feature as to their origin; they range through it in the most irregular manner, and are as variable in their length as in other respects. . . . . There is little reason to doubt that these masses have been thrust or squeezed into fissures in the upper part of the seam; in very few instances have they any connection with the floor. In nearly every case the thinnest part of the mass,—the wedge-like point,—is near the bottom of the seam, clearly showing that the openings took place at the top of the coal-bed, as we see in mud creeks in dry weather.

"The presence of the detached pieces of stone in the coal may be accounted for by the assumption of an unsolidified state of the vegetable matter of which the coal is composed, when the overlying bed was in course of deposition; and it is not at all an improbable supposition that portions of carbonaceous matter might get mixed with the sedimentary deposit which filled the openings, and thus account for the streak of coal in the stone. The evidence of pressure which caused a movement is afforded by the smooth markings of the stone, which are more especially observable near the top of the seam. . . . .

"We can imagine disturbances affecting the underlying strata in such a manner as to cause the seam to be disturbed, so that the upper part would be fractured and present openings which subsequent deposits would fill up; but we should expect the floor of the seam to exhibit corresponding irregularities. Such, however, is not the case; from its southern crop to the centre of the basin the bottom of the seam is regular in shape, and rests conformably on the strata beneath it, the plane of which is unbroken."

Cleat.

In some of the worked seams, such as that at Sydney mines, the direction of the cleat, or cleavage of the coal, so important in its economical working, is obscure, or rather there are no perceptible cleavage planes. In other cases, where most marked, they have been observed to coincide with the joints of the accompanying sandstones, and to be most prominent where the strata have been subjected to the greatest pressure.

The coal seams are, for the most part, overlaid by a stratum of argillaceous shale, very frequently characterized by the occurrence of erect stems of *Sigillaria*, often from two to three feet in diameter; in one instance, such a fossil stem, nearly five feet in diameter, was observed. The spreading roots of these trees (*Stigmaria*) of wonderful regularity and symmetry, rest upon the upper surface of the coal. This is a source of great danger in working the mines; and many serious and fatal accidents have occurred from the falling in of these masses.

Instead of the usual roof shales, the coal is often followed by sandstone, as occurs at intervals in the workings of the Sydney main seam, in the Collins seam at Little Bras d'Or, and in others. A bed of sandstone is almost invariably found to overlie the roof shales, at no great distance above the coal. This is so general that it often forms a useful guide in tracing the seams. At the Gowrie mine the floor of the seam is also sandstone.

In the section at the north side of Sydney Harbor, one of the lower coal seams in the series, six inches in thickness, with a thin clay parting in the middle, is seen, at one place, to be separated along the line of the *parting*, by the roots of an upright tree, which have apparently forced the layers asunder to the extent of six or eight inches, and for several feet from the extremities of the roots, beyond which the layers of coal again unite into one seam of the thickness first specified. In another instance, where a large upright tree appears rooted in a coal seam, the latter seems to have been actually bent down by the superincumbent weight, and at a little distance to have resumed its normal attitude. *

The general character and quality of the coal has already been given in the Report of Progress, 1872-73, page 240.

Total number and thickness of coal seams.

Taking the average of all the sections measured, the total number of seams in the productive measures, is twenty-four; of which six are three feet or upwards in thickness; and the total average thickness of coal may be stated at forty-six feet.

The upper portion of the Coal Measures is developed only to a limited extent in the western part of the field. In the central and eastern part it is entirely cut off by the sea. Its total thickness at Cranberry Head and at Point Aconi, where it is most fully developed, does not exceed 700 feet; it consists of the usual alternations of shale, sandstone, underclay, and coal.

Sections.

The sections given in this report, embrace the whole of the Coal Measures exposed in the Sydney coal field, and with the foregoing descriptions will sufficiently illustrate the nature and composition of the strata composing them.

Subordinate Basins in the Coal Field.

The anticlinal and synclinal folds, which have already been described as affecting the whole coal field, are well displayed along the sea coast where the high cliffs afford great facilities for studying their structure; and also for working the coal seams. The gentle upward slope of the strata from the sea, causes the Coal Measures in the several folds to rapidly run out inland, and thus only the south-western extremities of the coal seams are found on land, while the remaining and probably by far the larger portions must be sought beneath the sea. To what extent the sea area may be advantageously worked has to be proved. At the Sydney and Victoria mines, the seams have already been followed and worked for considerable distances under the sea, with satisfactory results. In all of these workings the dip appears to diminish in proportion to the distance from the outcrop.

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* Many additional interesting details in regard to the occurrence of fossil trees in these strata will be found in Mr. Richard Brown's papers in the Transactions of the Geological Society of London, already referred to; also in Dr. Dawson's Acadian Geology.

I shall now describe the subordinate basins from east to west.

THE COW BAY BASIN.

Cow Bay Basin.

Cow Bay has already been described in the Report of Progress, 1872-73, pp. 277, 285. On its shores, some of the most important coal seams of the entire field crop out, and for many years have formed the object of mining enterprise. These seams have been exposed both by natural and artificial means, on the northern shore of the bay, which has a general trend N. 40° E.; while the axis of the basin bears N. 69° E., and the anticlinal axis between this and the next adjacent basin to the west, runs N. 72½° E. On one side of the basin the strata dip N. 8½° W. < 8°; and on the opposite side, S. 31½° E., < 35°—42°. The entire series of strata (which does not, however, include the upper portion of the productive measures developed in other parts of the field) is exposed within a distance of three and a-half miles, measured along the north shore of the bay. The average breadth of the basin at the shore, between the outcrops of the lowest seam, does not exceed two and one-third miles; and it diminishes gradually inland, until it terminates at a point about six miles from the shore, as proved by several crop-pits and bore-holes on the various seams.

South Head.

On the southern shore, at Cape Morien, (or South Head, as it is commonly called), the extremity of a long projecting headland, which at the widest part is only thirty chains in breadth, some of the lower seams on the southern side of the basin crop out apparently in the direct line from their equivalents on the north shore, although with a considerable deflection of their strike to the east; thus proving the existence of an anticlinal in that vicinity. The coal seams and accompanying strata, in their further course eastward are cut off by the ocean; South Head thus constitutes the eastern extremity of the coal field, as exposed on land. Some of the seams at South Head are of workable thickness and good quality, and upon one of them a colliery has been established, which will be noticed in the sequel.

The following is an abstract * of the sections in descending order, on the northern and southern sides of the Cow Bay basin respectively, commencing at the axis which passes through the Block House mine.

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* The sections which follow are condensed from the larger detail sheets referred to at page 167. They are also illustrated on a small scale, in the sheet of grouped sections.

SECTION VIII.

COW BAY BASIN. NORTH SIDE. MILL BROOK TO NORTH HEAD.

Dip South 31½° *East* ∠ 38½° *(average.)*

	FEET.	IN.	FEET.	IN.
Strata, sandstone and shale			109	9
BLOCK HOUSE SEAM:				
Top coal	1	0		
Good coal	3	9		
Good coal (holing)	0	3		
Parting	0	0		
Good coal	4	2		
			9	2
Strata			8	6
COAL			0	1½
Strata, chiefly red and green marl, and sandstone			310	5
COAL (D.)			1	0
Strata			35	9
COAL and clay			0	9
Strata, chiefly grey sandstone			94	0
COAL (E.), overlaid by calcareo-bituminous *Naiadites* shale			3	2
Strata, with a thin band of calcareo-bituminous shale at base			118	0
MCAULAY SEAM:				
Coal, said to be	6	0		
Argillaceous shale	0	9		
Coal	1	0		
			7	9
Strata, sandstone and shale			215	10
SPENCER SEAM, (probably):				
Coal said to be			5	0
Strata			12	7
COAL			0	10
Strata			61	10
Carbonaceous shale and clay, in alternating thin bands*			3	2
Strata			26	7
COAL.				
Coal	0	1		
Argillaceous shale	2	0		
Coal	0	2		
Clay	0	3		
Coal	0	1		
			2	7
Strata			47	11

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* This is probably the equivalent of the McRURY SEAM, on the other side of the basin.

	FEET.	IN.	FEET.	IN.
COAL.				
Carbonaceous shale	0	1		
Argillaceous shale	0	6		
Coal	1	4		
Clay	0	3		
Coal	0	10		
			3	0
Strata, estimated in part Dip < 42° (Millstone Grit)...			180	0
LONG BEACH SEAM.				
Coal, thickness variable			1	4
Total thickness of strata			1259	0½
" " coal			32	6½

From the point where the above section terminates, to the anticlinal axis separating the Cow Bay and Glace Bay basins, a distance of upwards of half a mile, the rocks are, for the most part, concealed under the low flat expanse of Long Beach, beyond which they reappear, with greatly diminished dip; consequently, no exact measurement or estimate of the thickness can be given. The rocks underlying the Long Beach seam, as well perhaps as part of the above section, belong to the Millstone Grit.

The section on the south side of the basin, from its axis in the workings of the Block House mine, and in descending order is as follows:—

SECTION IX.

COW BAY BASIN. SOUTH SIDE. MILL BROOK TO HEAD OF COW BAY.

Dip North 8½° West < 8°.

	FEET.	IN.
Strata: sandstone and shale as before	109	9
BLOCK HOUSE SEAM:		
Coal: details of section as before	9	2
Strata	9	6
COAL	0	4
Strata	275	10
COAL (D.)—traces in concealed interval, probably	1	0
Strata	107	0
COAL (E.)—1 to 2 feet *	1	6
Strata	30	3
COAL and clay	0	7½
Strata	129	8

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* This seam is two feet six inches thick in the new shaft at the Gowrie mine.

	FEET.	IN.	FEET.	IN.
McAulay Seam:				
Coal	2	2		
Clay	0	0½		
Coal	2	8½		
			4	11
Strata			187	9
Upper Spencer Seam.				
Shale with coal streaks	0	10		
Coal	0	9		
Shale with plants	0	2½		
Coal	0	2		
Grey argillaceous shale	0	2½		
Coal	0	7½		
Dark-blue shale with plants	0	4		
Coal	0	7		
			3	8½
Strata with a thin coal seam and much carbonaceous matter			9	0
Lower Spencer Seam.				
Coal said to be 1′ 8″ to 2′ 4″			2	0
Strata concealed			7	10
Coal said to be seen at low tide on the reefs			0	8
Strata concealed			56	0
McRury Seam?				
Coal, irregular 6′ to 2′ 2″			1	4
Strata concealed			15	0
Coal, said to be visible at low tide			0	6
Strata concealed			215	0
Strata cut in boring near Black Brook			23	7
Long Beach Seam.				
Coal			3	1
Total thickness of strata			1205	0
" " coal			28	2½

The sections, although not exactly alike, are sufficiently near to establish the identity of the principal seams on the opposite sides of the basin. The lower part of the last section, from the Spencer seam downward, is very imperfectly seen on the north side of Cow Bay; but on the opposite shore, at South Head, as formerly remarked, the same strata are well exposed. Here, commencing at the *bill* of the Head, and at a point a little above the horizon of the McAulay seam, the following section is exhibited :—

SECTION X.

SOUTH HEAD, COW BAY. FROM THE HEAD WESTWARD.

Dip North 30° *East*, < 4° 15′.

	FEET.	IN.	FEET.	IN.
Strata			87	4
COAL			0	8
Strata, underclay and carbonaceous shale			1	9
McAULAY SEAM.				
Coal, good	1	9		
Coal, pyritous	0	10		
Clay	0	8		
Carbonaceous shale	0	1		
Coal	0	4		
Carbonaceous shale	0	1		
Underclay	4	0		
Coal	1	2		
Carbonaceous shale	0	2		
Coal	1	2		
			10	3
Underclay and argillaceous shale			10	6
Carbonaceous shale			0	2
COAL, coarse			0	6
Strata			201	9½
COAL, very irregular, average thickness			0	10
Strata			33	7
COAL			1	3
Clay			0	5
COAL, with shaly bands			0	5
Underclay			2	2
COAL, carbonaceous shale and clay in alternating thin bands			1	5
Underclay and argillaceous shale			7	2
SOUTH HEAD SEAM.				
Coal	3	4		
Clay	2	6		
Coal, canneloid	2	0		
			7	10
Strata			58	6
McRURY SEAM.				
Coal and carbonaceous shale	0	8		
Dark-green argillaceous shale	3	4		
Coal	0	3		
			4	3

	FEET.	IN.
Strata	67	4
COAL, coarse	1	6
Strata, with two thin beds of carbonaceous shale	80	0
COAL, with thin clay band	2	7
Underclay and argillaceous shale	11	0
COAL and carbonaceous shale	0	7
Strata	114	8
Carbonaceous shale passing into COAL	0	2½
Dark-blue argillaceous shale	3	0
COAL	0	3
Strata	26	4
COAL, variable thickness, average	0	4
Underclay and argillaceous shale	5	0
COAL	0	1
Strata	37	0
COAL and carbonaceous shale	0	6
Strata, closing with a nodular calcareous band	4	0
Total thickness of strata	785	2
do do coal	21	6½

Abrupt change in the strata.

This section at its base connects immediately and conformably with that given at page 176 as the section of the Millstone Grit on Mira Bay. The most remarkable difference here consists in the abrupt transition from grey argillaceous shale and sandstone, with a great profusion of carbonaceous beds, to red and green strata, almost entirely devoid of such beds.

In all the sections of the productive measures at Cow Bay and its vicinity, although calcareous matter is not entirely absent, it is very sparingly distributed, a remarkable exception to the general rule in this coal field. There are, however, two thin beds of calcareo-bituminous *Naiadites* shale, over two of the coal seams, and an impure nodular limestone at the base of the last section.

In comparing the section last given with those on the north side of Cow Bay, it will be observed that, although there is no strict accordance in details, the discrepancies are not greater than may be observed in other parts of the field where the continuity of the strata is unbroken; and although the coal seams are much more split up by clay and shale bands at South Head, yet the total quantity of coal, the approximate distances between the seams, and their geographical position in relation to their strike, appear to justify us in assigning to them the equivalency noted in the sections.

Collieries in the Cow Bay Basin.

Collieries in the Cow Bay Basin.—On the north side of this basin, the only collieries which have hitherto been established, are the Block House and Gowrie mines; full descriptions of which have already been given. (Report for 1872-73, pages 276, 286.) Since the date of that report, the pier or wharf at the Block House mine has been enlarged and strengthened, so as to give greatly increased facilities for loading, and security against storms.

Gowrie mines. At the Gowrie mines, a new shaft has been sunk about three quarters of a mile from the Odiorne pit, to cut the seam at the depth of 255 feet, on the extension of the north-west levels. It has been provided with all the requisite machinery and appliances for hoisting and pumping, and is connected by railway with the old works, and with the wharf.

Colliery at South Head. Near the extremity of South Head, a colliery was established about ten years ago, to work the South Head seam; the land area of which underlies about fifty acres. This seam is of considerable thickness, but irregular, and much mixed with shale and clay bands, and with impure and pyritous coal. The upper portion, however, three feet four inches in thickness, is of good workable quality.

In the earlier stages of the operations, the coal was worked by a slope from the crop, and a level or drift from the shore; but in 1866, when the lease became the property of a New York company, a vertical shaft was sunk—seventy-one feet in depth—to cut the seam about eighty yards from the crop, and considerably further inland. From the bottom of the shaft, a drift has been extended ninety yards to the dip, and levels driven about 150 yards, connecting the shaft with the former workings. The coal has been extracted, both to the rise and to the dip of the shaft; the bords being driven sixteen feet wide. Two steam engines of ten-horse power each, were employed at the surface for pumping and winding; and a light railway, a little over half a mile in length, was employed to convey the coal from the pit-mouth to a shipping wharf farther up the bay. **Wharf.** This wharf, on account of its exposed situation, has hitherto proved incapable of resisting the severe storms, and especially the pressure of drift ice, to which it has been exposed; consequently, the operations at this colliery have been intermittent, and were suspended at the date of my visit.

During the time it has been in operation, about 7,000 tons of coal, or an average of about 1,000 tons a year, have been raised, and for the most part sold. The coal is of excellent quality, remarkably hard and compact, and capable of withstanding exposure to the weather. As there can be little doubt that the seam may be worked to an indefinite extent under the sea, as well as on land, and as the overlying seam, which is probably also workable, will be accessible in this way, this mining property, from its advantageous position in other respects, must prove very valuable when the difficulty—which seems far from insuperable—in regard to a shipping place, is overcome.

THE GLACE BAY BASIN.

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Glace Bay
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The anticlinal axis separating the Cow Bay and Glace Bay basins, skirts the northern shore of Cow Bay at Cape Percy, or North Head. The opposite dips on either side of this axis are visible in the precipitous cliffs at and near the North Head; where the strata also afford evidences of an inconsiderable fault.

The Glace Bay basin presents a striking contrast to that of Cow Bay, the latter being comparatively narrow, with steep dips on one side, while the former is wide, and has uniformly gentle dips on both sides. The axis of the trough runs in a course N. 60° E., or about twelve degrees farther to the north than the anticlinal axis; and it is cut off obliquely by the shore line in a direction nearly at right angles to that of Cow Bay. It is also traversed longitudinally by the two parallel valleys of Great and Little Glace Bay brooks. Great Glace Bay brook widens into an extensive tidal lake or lagoon; and the direction of both valleys coincides with that of the north shore of Cow Bay. As there is no fault or break in the continuity of the strata throughout the entire basin, the valleys are obviously due to denudation.

This basin embraces, in addition to the beds exposed in that of Cow Bay, 610 feet of strata, overlying the highest of those last named; and in these upper beds includes besides several minor coal seams, one of very great importance—the Hub seam—the highest workable coal seam in the series in this district. The Hub seam, in so far as regards its land area, underlies a superficial extent of only 150 acres, at the extremity of the promontory of Table Head and Burnt Head. The next underlying workable seam,—the Harbor seam—the equivalent of the Block House seam of Cow Bay is also very partially exposed on land, having an available area of 2,343 acres. These two seams, being cut off by the sea on either hand, in the direction of their crop, as well as to the dip, present on the map the appearance of segments of concentric circles; as do also the underlying seams and accompanying strata. The latter, however, continue their course on land in an easterly direction, and in a straight line (with very slight undulations) for a distance of about seven miles, as far as North Head; and are more or less exposed throughout that distance. The Phelan is the next great seam, underlying the

Harbor seam. In this basin it has been worked at the Bridgeport, Reserve, Caledonia and Clyde mines. It represents the McAulay seam of Cow Bay.

The attitude of all the seams in the Glace Bay basin (extending for a length of about twelve miles), as ascertained by careful measurement, and recorded on the map, is a striking proof of the general regularity of deposit and absence of faults which characterize this district.

General regularity of the measures and absence of faults.

The following section shows that there is, however, a considerable thickening of the beds between the several coal seams, as they are traced eastwards.

SECTION XI.

GLACE BAY BASIN. TABLE HEAD TO NORTH HEAD.

Dip North. < 5° 12′.

	FEET.	IN.	FEET.	IN.
Strata			99	6
COAL, good			1	0
Strata, chiefly argillaceous shale			56	0
HUB SEAM.				
Coal	0	10		
Clay	0	0½		
Coal	0	3		
Clay	0	1		
Coal, good	5	6		
Splint or coarse coal	0	1		
Coal, good	3	0		
			9	9½
Strata			20	3
CANNEL SEAM.				
Coal, cannel	0	1		
Carbonaceous shale	0	1		
Coal, cannel	0	8		
Coal, bituminous	0	6		
Clay	0	1		
Coal	0	3		
			1	8
Underclay with coaly matter			5	7
COAL (cannel) and carbonaceous shale with clay			0	8½
Strata, with cannel-slate, and calcareo-bituminous shale			103	0
COAL, cannel-slate, calcareo-bituminous shale and clay			1	9
a. Strata, including one very thin non-persistent coal			38	0
COAL, good			0	3½
Strata			75	6

	FEET.	IN.	FEET.	IN.
COAL.				
Coal, bituminous	0	1½		
Impure cannel	0	7		
			0	8½
b. Strata, with many fossiliferous limestone bands			118	9
HARBOR SEAM.				
Coal	0	2		
Clay	0	0½		
Coal, good	5	0		
			5	2½
Strata			21	10
COAL and clay in three bands			1	7½
Strata, with fossiliferous limestone beds			148	3½
COAL			0	2½
Strata, with one fossiliferous limestone bed			57	3
COAL			0	7
Strata			20	6
COAL, carbonaceous shale and clay			0	10
Strata			27	1
COAL and carbonaceous shale, in three bands			0	3
Strata			20	9
BOUTHILLIER SEAM.				
Coal, cannel	0	11		
Coal, good, bituminous	1	1		
			2	0
Underclay and shale			4	4
COAL			0	7
Strata, with fossiliferous limestones and *Naiadites* shale at the base			69	3
c. BACK PIT SEAM.				
Coal			2	0
Strata			112	9
d. PHELAN SEAM.				
Coal			7	3
Strata			58	10
Coal and carbonaceous shale			0	6
Strata			63	5
COAL and carbonaceous shale with fossils			0	8
Strata			26	4½
COAL and clay in three bands			0	7
Strata			37	10
ROSS OR EMERY SEAM.				
Coal	3	4		
Clay	0	2		
Coal	2	0		
			5	6

	FEET.	IN.
Strata	30	2
COAL, cannel, good	0	10
Strata, chiefly massive sandstone	33	1½
COAL and shale in nine bands, a very variable seam	3	0
Strata, very rich in vegetable remains	15	9
MCRURY SEAM.		
Coal, clay and carbonaceous shale in eight bands	3	0
Strata (Millstone Grit), including one very massive sandstone, 100 feet thick	175	3
COAL	1	6
Underclay and arenaceous shale	9	6
DIRTY SEAM.		
Coal	0	1½
Strata	23	7
COAL, chiefly cannel, and underclay in three bands	3	8½
Strata	8	0
LORWAY OR GARDINER SEAM.		
Coal, canneloid in part	3	0
Strata	36	1
Total thickness of strata	1574	7
" " coal	50	4

The continuation of this section downward (an abstract of which is given at page 181), is in rocks which, like those in the Cow Bay sections, are chiefly distinguished from those above enumerated by the prevalence of red and green sandstones and shales, and the extreme irregularity and poverty of the beds containing carbonaceous matter.

The following explanatory notes refer to the above section :

(*a.*) At this point, in the section, the fossiliferous limestone beds commence, none being found above it.

(*b.*) The following section, obtained from a careful record of the sinking of the new or Sterling Pit, at the Little Glace Bay mines, embraces all the strata comprised within a thickness of 234 feet, immediately overlying the Harbor seam. Elevation of pit mouth above the sea, eighty feet :

Section of the Sterling Pit.

Surface soil and clay	14	9
Blue argillaceous shale	13	6
Red marl	4	2
Sandstone	0	7
Blue argillaceous shale	6	6
Sandstone	5	7
Blue argillaceous shale	6	2

	FEET.	IN.
Red marl, with brown streaks	3	6
Dark-blue sandstone	0	6
Blue argillaceous shale	8	0
Mixed argillaceous shale and sandstone	5	1
Highly calcareous, bluish-grey sandstone	0	8
Fireclay	5	0
Sandstone and argillaceous shale	10	11
Calcareo-bituminous shale; *Naiadites*, fish scales, &c	0	2
Fine blue sandstone and shale in bands	8	2
Calcareo-bituminous shale; shells and coprolites	0	4½
Fine-grained bluish-grey sandstone	2	5
Fireclay	2	0
Sandstone with nodules of chert	6	11
Black or dark-blue argillaceous shale with *Naiadites*; sometimes a limestone, or impure cannel	1	0
Argillaceous underclay	4	0
Sandstone	1	1
Argillaceous shale	0	3½
Sandstone	1	5
Argillaceous shale	0	2
Sandstone	0	7
Argillaceous shale	1	11
Sandstone	1	6
Blue argillaceous shale	1	5
Black or brown argillaceous shale	4	1
Sandstone	0	8
Bluish argillaceous shale	0	2½
Dark-blue argillaceous shale	13	6
Calcareo-bituminous shale; *Naiadites*	0	1½
Sandstone	0	4½
Calcareo-bituminous shale; *Naiadites*	0	2
Sandstone	0	2½
Blue argillaceous shale	0	10½
Sandstone	0	7
Dark-blue argillaceous shale	1	6
Sandstone	4	0
Blue argillaceous shale	1	0
Calcareo-bituminous shale; *Naiadites* and fish scales	0	8
Grey sandstone of rather coarse grit	1	7
Blue argillaceous shale, ironstone nodules	18	6
Light-bluish grey, calcareous sandstone; quarried at McPherson Point; makes a good building stone	21	7
Blue argillaceous shale	1	4
Sandstone	2	8
Argillaceous shale and sandstone in bands	8	0
Impure cone-in-cone limestone	0	5

	FEET.	IN.
Light blue and grey, fine-grained sandstone, in wedge-shaped masses ("Liver-rock")	2	8
Argillaceous shale and sandstone	2	2½
Coarse-grained grey sandstone	6	7
Mixed argillaceous shale and sandstone	13	3
Hard grey calcareous sandstone	0	10½
Calcareo-bituminous shale (*Naiadites*, &c.)	0	7
Hard, brown sandstone, (lenticular)	0	10½
Dark blue limestone; shells, coprolites and fish scales	0	5
Mixed argillaceous shale and sandstone	6	2
HARBOR SEAM:		
Coal	6	2
	240	2

(*c.*) The Back Pit seam, as specified in the general section, is given from measurements in the cliffs on the south side of Great Glace Bay. The section of the same seam obtained in sinking the engine pit at the Caledonia mine, is as follows:—

Section of the Back Pit seam.

	FEET.	IN.	FEET.	IN.
Coal	1	4		
Carbonaceous shale	0	2		
Coal	0	8		
Fireclay	0	1		
Coal	2	6		
			4	9

(*d.*) The Phelan seam is six feet two inches thick at the Reserve mine; eight feet at the Caledonia mine; and six feet six inches at the Clyde mine.

(*e.*) The Ross or Emery seam is very variable in thickness, showing, even in the limited extent of the workings at the Emery mine, a difference of one foot; being four feet nine inches at the west, and five feet two inches at the east end of the main level. The section of this seam is from a boring on the sea shore at Schooner Pond mine; that in the general table of worked seams (Report for 1872-73, page 291) was measured in the slope at the same mine. The following are sections of the same seam at two different points still farther east:—

Sections of the Ross or Emery seam.

EAST SIDE OF SCHOONER POND.

	FEET.	IN.
Coal, good	1	1½
Coal and clay	0	3½
Clay	0	7½
Coal	0	2
Clay	0	0½

	FEET.	IN.
Coal	0	1
Clay	0	0½
Coal, good	0	2
Clay, parting	—	—
Coal	0	5
Clay, parting	—	—
Coal	2	0
Clay	0	0¼
Coal	1	5
Total thickness	6	4¾

NORTH HEAD OF COW BAY.

	FEET.	IN.
Coal	1	9
Coal, impure cannel and clay	0	3
Underclay, argillaceous	2	6
Coal	0	10
Clay, parting	—	—
Carbonaceous shale	0	2
Coal	4	5
Total thickness	9	11

The section of the measures in the Glace Bay basin at the north-western or Bridgeport side, commencing at the same point as in the previous section, is as follows:—

SECTION XII.

GLACE BAY BASIN. TABLE HEAD TO BRIDGEPORT.

Dip North, 85° *East*, $< 3°$.

			FEET.	IN.
Strata, as in the previous section			99	6
COAL			1	0
Strata			54	6
COAL, slaty cannel and carbonaceous shale, with much calcareous matter			2	3
HUB SEAM:				
Coal, section as in Table, (Report for 1872-3)			9	4½
Strata			25	1
a CANNEL SEAM:				
Coal, cannel	1	2		
Coal, ordinary bituminous	0	9		
			1	11

	FEET.	IN.	FEET.	IN.
COAL, clay and carbonaceous shale, in eleven bands....			1	9
Strata			17	2½
COAL, good			0	4
Strata, chiefly red and green marl and shale...........			89	0
COAL, shaly, impure cannel			0	9
Strata, with many fossiliferous limestone beds........			89	1
COAL			0	5
Strata			14	3
COAL, good			0	2
Strata			99	10
COAL, impure cannel			1	8
Strata, chiefly limestone in five beds................			2	10½
b HARBOR SEAM :				
Coal, section as in Table, (Report for 1872-73).....			6	1
Strata			17	0
COAL, clay and calcareo-bituminous shale, in nine bands			3	2½
Strata			124	10
COAL, impure cannel			0	2½
Strata; much fossiliferous limestone.................			75	3
COAL, carbonaceous and argillaceous shale in three bands			0	5
Strata			14	3
COAL; impure slaty cannel........................			0	6
Strata, with a limestone band at the base............			5	8
BOUTHILLIER SEAM :				
Coal, not well seen			4	0
Strata, partly concealed, probably a thin coal at top....			92	1
BACK PIT SEAM :				
Coal, long reed	1	10		
Carbonaceous shale, pyritous..................	0	3		
Coal, good	1	11		
			4	0
Strata			49	5
COAL			0	1
Strata			26	0
COAL, carbonaceous and argillaceous shale in nine bands			2	2
Strata			5	7
c PHELAN SEAM :				
Coal	3	0		
Clay	0	4		
Coal	5	3		
			8	7
Strata, with some fossiliferous limestone beds.........			47	2
COAL and clay, in seven bands......................			2	3
Strata; one limestone bed, rich infossils			58	8

d ROSS OR EMERY SEAM :	FEET.	IN.	FEET.	IN.
Coal			1	8
Strata, mostly concealed; probably a coal seam, the equivalent of the McRURY SEAM, occurs here			169	9
COAL, coarse, carbonaceous shale and clay			2	5
Strata, chiefly sandstone (Millstone Grit)			107	0
LORWAY OR GARDINER SEAM.				
Coal	4	9		
Clay	0	6		
Coal	0	6		
			5	9
Strata			63	0
Total thickness of strata			1,407	11½
Do. do. coal			51	10½

The precise point in this section, at which the Millstone Grit gives place to the productive measures, is by no means clearly established; but it is believed to be approximately as here stated. It will be observed, on comparing sections XI and XII, that although the total thickness of coal on the north-west side of the basin is a little in excess of that on the opposite side, the aggregate thickness of strata in the latter, is 173 feet more than in the former; and this excess of thickness is distributed nearly proportionally, in the intervals between the several coal seams.

Cannel coal.

The following explanatory notes refer to Section XII.

(*a.*) *Cannel seam.*—The occurrence of cannel and canneloid coal in this, and in some of the other basins, has been frequently noted. From the general presence of obscure fossil forms, of a brackish-water type, including fish scales, teeth, coprolites, *Cythere*, &c., and from the large proportion of earthy impurities associated with such beds, Dr. Dawson has suggested that they owe their origin to the accumulation of fine vegetable mud or muck, in the shallow ponds and lagoons of the carboniferous period. They are generally too thin to be profitably worked; but in this instance it may be otherwise. It is the most important cannel coal that has been observed in this field, and attempts were made on a small scale, several years ago, to work it; why these were abandoned, I am not aware.

Analysis by Professor How.

An analysis of the coal was made by Professor Henry How, of Windsor, N.S., which, together with his accompanying remarks, are here reproduced :—

"A specimen from an eighteen inch seam at Little Glace Bay, had the appearance of cannel coal; gave a brown powder, and brownish-black streak; burned alone when well heated in a flame; in a closed tube gave much volatile matter, and left a rounded swollen coke.

Proximate analysis gave:—

	FEET.	IN.
Moisture	0	83
Volatile combustible matter	30	07
Fixed carbon	44	42
Ash	24	68
	100	00

"The amount of ash here, though considerable, is smaller than that in the well-known Scotch cannel from Capeldrae, which gave, according to Fyfe, 25·40 per cent. The volatile combustible matter is evidently high enough, in proportion to the fixed carbon, to mark the class of minerals to which the specimen belongs."

Sections of the Harbor seam.

(*b*) *Harbor seam.*—The sections of the Harbor seam given in the general table in the previous report, are measured in the working pits of the International and Little Glace Bay mines respectively; while that given at page 214 of this report, is taken at the sea shore, near McPherson Point. They exhibit no great variation in thickness or quality; and this seam and its equivalents in the other districts, may be regarded as the most regular and valuable in the entire coal field.

A representative sample from the International mine, at the depth of 100 feet, was analysed by Professor Chapman, of Toronto, and gave:

Analysis by Professor Chapman.

	FEET.	IN.
Moisture	0	87
Volatile combustible matter	35	41
Fixed carbon	58	56
Sulphur	trace	
Ash	5	16
	100	00

(*c*) *Phelan seam.*—The section of the Phelan seam given above, is that afforded by the sea cliffs at Bridgeport. At the distance of half a mile from the shore, in the main level of the old Bridgeport mine, the shale parting had increased in thickness to twenty-eight feet; and in a borehole, 300 yards to the dip of the level, it was found to be only fourteen inches thick, the upper bench of the coal being three and a half feet, and the lower, six feet in thickness.

(*d*) *Ross seam.*—The remark already made with regard to the irregularity of the Ross seam is confirmed by the last section; it is found at and near the Bridgeport shore to be only one foot eight inches in thickness; while, at the Emery mine, not quite two and a-half miles distant to the east, it is four feet nine inches and five feet ten inches at the west and east ends respectively.

Irregularities in the coal seams.

These irregularities of the coal seams are greater in the lower seams; and, consequently, considerable difficulty has been experienced in tracing the Lorway or Gardiner seam, and that immediately overlying it.* In sinking the west pit at the Lorway mine, the following section occurs, which it is difficult to reconcile with either of those given above:

SECTION XIII.

LORWAY WEST PIT.

Dip North 25°. *East* < 5°.

	FEET.	IN.	FEET.	IN.
Bluish grey sandstone			10	0
Bluish argillaceous shale, with partings			7	0
DIRTY SEAM:				
Coal	0	5		
Carbonaceous shale	0	6		
Coal	0	3		
Clay	0	1		
Coal	0	6		
Clay with coal pipes	2	8		
Coal	1	0		
			5	5
Argillaceous underclay			5	0
Clay, and fine-grained coherent sandstone, with ironstone nodules			2	10
Grey argillaceous shale			13	3
Blue argillaceous shale			6	6
LORWAY SEAM:				
Coal	1	7		
Clay	0	1		
Coal	1	10		
Clay	0	0¼		
Coal	0	6		
			4	0¼
Total thickness of strata			54	0¼
" " coal			7	9

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* At the date of my previous report—1872-73—containing detailed descriptions of the various collieries in operation, there seemed reason to believe that the coal seam worked at the Gardiner mine was distinct from that opened in the Lorway mine, and underlay it at a considerable depth. Subsequent investigations, however, seem to establish their identity. It may be here also explained that in the former report the statements given in several instances of the thickness of strata between the various seams do not accord with those in the sections now given. In all such cases the latter are to be regarded as correct; being based upon actual measurements of the several beds, while the former were estimated from angles of dip.

It may here be mentioned that it is stated on good authority, that at the Gardiner Mine, in the immediate vicinity of the engine shaft, although apparently not cut in sinking that shaft, there occurs a series of strata of coal and clay in thin bands, with an aggregate thickness of five feet, overlying the Gardiner seam, at a distance of thirty-four feet. This coal group would represent the so-called Dirty seam of the above section, and bring all the facts into near accordance with those observed in other parts of the field.

As regards the collieries in the Glace Bay district, there are no facts to be noted in addition to those already given in the Report for 1872–73.

SYDNEY HARBOR BASIN.

In the further extension of the Coal Measures westward, the next basin which comes under notice is that of Sydney Harbor, which includes the Lingan, Low Point and Sydney mines districts. It extends from Indian Bay and Bridgeport Basin, as far as Point Aconi, and embraces all the coal seams in the field.

Bridgeport anticlinal.

An anticlinal axis, which skirts the north shore of Bridgeport Basin, and runs thence westerly to a point midway between McPhee and McKay Brooks on Sydney Harbor, divides this basin from that of Glace Bay, as the parallel North Head anticlinal divides the latter from the Cow Bay basin.

On the north side of this axis the rocks dip at angles varying from 12°—16° at Lingan, to 40° at the Victoria mines. The sea coast follows the fold of the strata in such a manner as to bring the entire volume of the Coal Measures upon the cliffs in several fine sections. From Low Point lighthouse to Lingan the strike of the rocks is nearly parallel to the shore—for a considerable distance quite so. The section has been carefully measured, and is, in abstract, as follows:—

SECTION XIV.

SYDNEY HARBOR BASIN. LOW POINT TO LINGAN.

Dip North 19° *West, to North* 8° *East* < 10°—15°

	FEET	IN.
Measures concealed from lighthouse southwards, estimated from the nearest available angle of dip, N. 10° E. < 15°	542	0
COAL, seen only at low tides; said to be about	3	0
Strata, mostly concealed; one grey sandstone reef	68	0
Strata; much red marl	208	4

	FEET.	IN.	FEET.	IN.
UPPER CARR SEAM:				
Coal and clay	0	11		
Clay	0	1		
Coal	0	10		
Clay	0	3		
Coal	1	2		
			3	3
Strata, underclay, argillaceous and arenaceous shale			28	0
COAL			0	2
Underclay			1	10
LOWER CARR SEAM:				
Coal			3	2
Strata; red and green marl and calcareous sandstone			157	11
COAL; impure, with clay bands			2	2
Strata, partly concealed			30	0
BARASOIS SEAM:				
Coal	3	0		
Fireclay	3	0		
Carbonaceous shale	0	3		
Coal	5	10		
			12	1
Strata; chiefly coarse-grained yellow sandstone			56	10
COAL, and carbonaceous shale			0	11
Strata			3	6
COAL.				
Coal	1	4		
Carbonaceous shale	0	1½		
Coal	0	10		
			2	3½
Strata; underclay and arenaceous shale			14	0
COAL, carbonaceous shale and clay; sometimes all coal.			1	0
Strata; three small coal seams and many fossiliferous limestones			96	6
COAL, canneloid			0	5½
Strata			21	0
COAL			0	4½
Strata			13	8
COAL			0	4
Strata; much red and green marl			75	8
COAL, irregular			0	8
Strata; many beds of fossiliferous limestone and carbonaceous shale			87	10½
COAL			0	1½
Strata; argillaceous shale, upright trees and many plants			4	0

	FEET.	IN.	FEET.	IN.
David Head Seam :				
Coal, good	2	1		
Clay, parting	—	—		
Coal, very good	5	11		
			8	0
Strata			13	6
Coal			1	3
Strata; underclay and sandstone			18	0
Coal and shale in five bands			2	11
Strata; many bands of fossiliferous limestone and carbonaceous shale			160	7
Coal.				
Coal	1	0		
Carbonaceous shale	0	4		
Coal	0	1½		
Carbonaceous shale	0	9		
			2	2½
Strata			36	6½
Coal			3	0
Strata ; many calcareo-bituminous fossiliferous beds			64	3
Coal.				
Coal	0	5		
Carbonaceous shale	0	1½		
Coal	0	5½		
			1	0
Strata, terminating in calcareo-bituminous *Naiadites* shale			12	10
Northern Head Seam :				
Coal			4	0
Strata, including a coarse conglomerate			75	11
Lingan Main Seam :				
Coal, good	1	2		
Coal, pyritous	0	2		
Coal, good	0	11		
*Clay	0	1		
Coal	5	8		
			8	0
Strata, with one irregular limestone bed			41	0
Coal and clay, in five bands			0	8
Strata, much calcareo-bituminous *Naiadites* shale			6	11
Coal, shale and clay, in eleven bands			3	8

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*See Report for 1872-73, p. 249.

	FEET.	IN.	FEET	IN.
Strata, chiefly green marl, and one limestone bed			37	4½
COAL			0	7
Strata			5	1
COAL.				
Coal	0	3		
Argillaceous shale	0	2		
Coal	2	1		
			2	6
Strata, underclay and arenaceous shale			7	6
COAL, carbonaceous shale and clay			0	7
Strata, underclay, &c			8	6
COAL			0	7
Strata, chiefly bluish sandstone, streaked with black (Millstone Grit)			177	0
COAL.				
Traces of a coal seam exist here, but nothing positively known				
Strata, partly estimated; sandstone and argillaceous shale			104	0
COAL.				
Traces of a coal seam, but not seen in place				
Strata; sandstone, estimated dip < 8°			45	0
COAL probably the representative of the LORWAY SEAM			1	0
Strata			50	0
Total thickness of strata			2343	2
" " coal			58	8

Low Point section.

Low Point, which is situated at the eastern entrance of Sydney Harbor, and at the extremity of which stands the lighthouse, is an extensive level spit or cape, composed of clay and gravel, showing no exposures of rock for a distance of about half a mile on the dip. This space is, however, estimated, and the thickness included in the section, as if underlaid by the rocks which, from the *debris* in the bank and on the beach, probably consist of red and green marl and grey sandstone. Exclusively of this, the section embraces a thickness of 348 feet 10 inches, for the most part exposed, of strata overlying the highest of those in the Glace Bay section, and including an aggregate thickness of ten feet three inches of coal in five distinct seams, one of which, at least, is workable.

The lower portion of the above section is very doubtful as regards the coal seams, which, with the exception of the last, are only indicated by obscure traces at the sea shore. The lowest seam, which I believe to represent the Lorway or Gardiner seam, is very much reduced in thickness; and is seen at water level on the sea shore to be entirely nipped out by the sandstone within which it is enclosed.

The section at the west end of the Lingan tract, along the shores of Sydney Harbor, from the lighthouse towards the town of Sydney, is well exposed, with the exception of the part occupied by the low, flat expanse of sand and gravel at the summit. The rock exposures commence about three quarters of a mile from the lighthouse. The following is an abstract of the section:—

SECTION XV.

SYDNEY HARBOR BASIN. LOW POINT TO MCPHEE'S FERRY

Dip, North 26° West to North 6° East, $<$ 40° *to* 24°.

			FEET	IN.
Measures concealed, including the uppermost seam....			707	6
Coal, in thin layers, much mineral charcoal...........			1	6
Strata			18	8
Paint Seam:				
Shale and coal..................................	1	3		
Coal..	1	0		
Underclay.......................................	1	7		
Coal..	1	0		
Shale...	0	4		
Coal..	3	0		
Shale	1	2		
Coal..	4	0		
			13	4
Strata, chiefly red and green marl and sandstone			155	6
Coal..			0	6
Strata			20	3
Crandall Seam:				
Coal..			4	9
Strata...			38	2
Lyle Seam:				
Coal..			3	2
Strata...			11	7
Coal..			1	4
Strata mostly concealed, probably red and green marl..			192	8
Coal..			0	6
Strata, including calcareo-bituminous, fossiliferous limestone..			72	10

	FEET.	IN.	FEET.	IN.
VICTORIA SEAM:				
Coal, poor	0	7		
Coal, good	6	0		
			6	7
Strata, including some thin, irregular bands of coal			53	6
COAL.				
Coal	0	6½		
Clay	0	1		
Coal	0	3½		
			0	11
Strata, many fossiliferous limestones, one cone-in-cone bed			122	11
COAL.				
Coal	0	2		
Clay	0	3½		
Coal	1	0		
			1	5½
Strata			62	11
COAL			0	4
Strata			28	1
COAL			0	6
Strata			17	10
COAL			0	2
Strata			20	0
WILLIE FRAZER SEAM:				
Coal, good	3	0		
Coal, bad	0	6		
			3	6
Strata, with calcareo-bituminous *Naiadites* shale at base			83	11
NUMBER THREE SEAM:				
Coal			4	0
Strata; much fossiliferous limestone; one bed a mass of *Cythere*, *Spirorbis*, &c., slickensided			67	6½
COAL			0	8
Strata			48	1
HUGH MCGILVARY SEAM:				
Coal	5	0		
Bluish argillaceous shale	0	6		
Coal	0	9		
			6	3
Strata, with some irregular layers of coal			61	2
COAL			1	3
Sandstone			4	6

	FEET.	IN.	FEET.	IN.
COAL, calcareo-bituminous, fossiliferous shale and argillaceous shale; in six bands			2	2
Strata, with one thin bed of fossiliferous limestone			57	5
DAN. MCGILVARY SEAM:				
Coal	0	7		
Clay	0	0½		
Coal	0	10½		
Carbonaceous shale	0	1		
Coal	0	7		
			2	2
Strata, with one thin seam of coal and clay			17	0
COAL			0	7
Strata, chiefly coarse grey sandstone; a little coal in patches (Millstone Grit)			343	10
COAL (probably the LORWAY SEAM)			0	10
Underclay and arenaceous shale			6	0
Total thickness of strata			2268	4
" " coal			54	5

The Millstone Grit may be said to commence at the point indicated in the section. The Frazer or Mullins seam, with six feet of good coal at the outcrop on the sea shore, is 633 feet, 5 inches below the base of this section, the interval being occupied by rocks of the nature above described. (See p. 185.)

Position of the Frazer or Mullins seam.

In the Victoria seam there are some remarkable peculiarities which have been noted and described in the Report for 1872-73, p. 255; and which seem to assimilate this seam to that worked at the Block House mine at Cow Bay, with which, on other grounds, it appears undoubtedly to be identical. It is also worthy of remark—as it has been suspected by some that the high angle of dip may be connected with a fault which, occurring under the sea, might be fatal to the works at the Victoria mines—that in sinking on the seam farther to the dip, the angle gradually but sensibly diminishes; from which, as well as from other circumstances, it may reasonably be inferred that no break in its continuity is likely to exist.

Identity of the Victoria and Block House seams.

Collieries in the Lingan Tract.—With the exception of those enumerated and described in the previous report, there are no other points at which coal has been systematically worked in this district, although it has been extracted on the crop of the seam, at several places, by the neighbouring farmers. At the Lingan mine, owing to an accident which had occurred at the old works, a new upcast shaft for

Collieries in the Lingan Tract.

ventilation, has recently been sunk, sixty-five feet in depth, considerably to the northward of the former. At the Barasois mine, which was opened by the General Mining Association, chiefly for the purpose of working their sea-area, operations were resumed last season, on a small scale, but resulted in the discovery that, at that point, there was not sufficient cover over the seam to render such workings safe; and they have consequently been abandoned for the present. At the Victoria mine, the slope, which was previously 615 feet in length, * was sunk last season 135 feet further to the dip, and levels driven east and west to a considerable extent with most satisfactory results.

Sydney Mines District.—On the opposite shore of Sydney Harbor, two miles from Victoria mines, is the Sydney mines district, the seat of the most extensive and prosperous mining operations on the island. It extends in a north-westerly direction, a distance of about five miles, with an average breadth of two and a half miles, being separated from the Boulardrie district by the Little Bras d'Or.

Symmetry between the Glace Bay and Sydney Harbor basins.

There is a most perfect symmetry between the Glace Bay basin and that of Sydney Harbor, as is shown by the fact that the coal seams and accompanying strata in their strike from the shores of Indian Bay to Sydney mines, are parallel to those of the Glace Bay basin on its south-eastern side, as are also the Bridgeport and North Head anticlinals respectively; and there appears to be no such difficulty as has been felt by previous observers in correlating the seams on the opposite sides of the harbor, without having recourse to the agency of faults, of the existence of which, in the productive measures here, there is no evidence. This area is occupied by the extreme western end, and a small part of the south-east side of the basin; the rest, as far as Low Point, being hidden under the waters of the harbor. The opposite side of the basin is affected by an anticlinal axis running through Big Pond and the valley, stretching southward. The measures, in their extension westward, are thus deflected inland. On the crown of this subordinate anticlinal, which appears to run out at a very short distance from the shore, the crops of the Sydney main seam and of all those overlying it, are broken off by the encroachments of the ocean, and by the erosion which has originated the lagoon and valley of Big Pond. For a considerable distance at the west end of the district, however, the land area includes all the coal seams, as high as the Lloyd Cove seam, the shore line being approximately parallel to the strike of the measures.

Absence of faults.

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* Erroneously stated in a former report as 850 feet.

Section north shore of Sydney Harbor.

The section along the north shore of Sydney Harbor is remarkably well exposed; the cliffs being high and the angle of dip, which nearly coincides with the direction of the shore-line, also sufficiently high to show clearly the order of succession; and the concealed intervals are unimportant. This section has been measured and recorded with great minuteness of detail by Mr. Richard Brown, as before mentioned. The subjoined abstract, reduced for the most part from my own measurements, will be found to differ from Mr. Brown's, chiefly in the diminution of the thickness assigned by him to the only concealed interval in the whole section, namely, that occurring at Lloyd Cove, which we are now enabled to fill up accurately from the pit section at the New Winning, recently completed.

SECTION XVI.

SYDNEY HARBOR BASIN—CRANBERRY HEAD TO STUBBART POINT.

Dip North 57° *to* 42°, *East* < 4° *to* 10°

	FEET.	IN.	FEET.	IN.
Strata; sandstone and argillaceous shale			21	7
CRANBERRY HEAD UPPER SEAM.				
Coal			3	8
Strata; numerous erect trees, and underclays rich in *Stigmaria*			15	8
CRANBERRY HEAD LOWER SEAM.				
Coal	0	3		
Clay	0	0¼		
Coal	0	9		
			1	0¼
a Strata; much calcareous sandstone, and red and green marl			245	8
COAL.				
Coal and carbonaceous shale	0	6		
Clay	0	0¼		
Coal	0	1½		
Blue argillaceous shale	0	8		
Coal	0	4		
			1	7¾
Strata; underclay, arenaceous, argillaceous and carbonaceous shale			17	4
b LLOYD COVE SEAM.				
Coal	2	3		
Clay	0	1½		
Coal	0	6		

	FEET.	IN.	FEET.	IN.
Clay	0	0¼		
Coal	2	7		
Clay	0	0¼		
Coal	0	10		
			6	4
Strata; mostly concealed under the beach at Lloyd Cove.			110	4
COAL			0	5
Underclay			4	6
COAL.				
Coal	0	5		
Clay	0	1½		
Coal	0	3		
			0	9½
Strata			47	0
c CHAPEL POINT UPPER SEAM.				
Coal	0	8		
Black shale and coal	0	1		
Clay and shale	0	4		
Coal	0	4		
Carbonaceous shale (*Cordaites*)	0	2½		
			1	7½
Strata; underclay, &c			9	0
COAL			0	3
Strata; chiefly a strong sandstone, forming a reef			42	6
COAL			0	9
Underclay			1	10
COAL			0	8
Strata; mixed with a little coal			8	4½
COAL			0	9½
Strata			15	8
COAL and shale			0	10
Strata; chiefly laminated sandstone			23	9
c CHAPEL POINT LOWER SEAM.				
Coal	1	5		
Clay	0	3		
Argillaceous shale and bad coal	0	6		
			2	2
Underclay			2	6
COAL			0	4
Strata; underclay and blue argillaceous shale			13	7½
COAL; coarse and pyritous			0	2
Underclay			2	0
COAL; good and bright, with threads of carbonate of lime			0	2½

	FEET.	IN.	FEET.	IN.
d Strata; much red and green shale, over very heavy sandstone			129	6
Coal			0	5
Strata; much calcareous matter in the shales and sandstones			68	7
Coal and shale mixed irregularly and unevenly			1	7
Strata; chiefly shale and limestone; both rich in fossils			100	4½
e Sydney Main Seam.				
Coal, good	4	4		
Parting	—	—		
Coal, good	1	8		
			6	0
Strata			39	11
Coal			0	9
Underclay, much ironstone, and layers of carbonaceous shale			11	0
Coal			0	4
Strata; red and green marl, fossiliferous limestone and sandstone			126	4½
Quarry Seam.				
Coal	0	2		
Carbonaceous shale	0	1		
Coal	0	3		
Carbonaceous shale	0	2		
Coal	0	3		
			0	11
Strata; chiefly red and green marl, and argillaceous shale			72	6
Coal			0	5
Strata; chiefly sandstone and arenaceous shale			39	8
Strata; many thin fossiliferous limestone bands, and calcareo-bituminous *Naiadites* shale at the base			116	11
f Indian Cove Seam.				
Coal	0	1½		
Argillaceous shale and clay	0	4½		
Coal	0	2		
Clay	0	1		
Coal	4	0		
			4	9
Strata			60	10½
Coal			0	11
Strata			25	2

	FEET.	IN.	FEET.	IN.
COAL.				
Coal	0	8½		
Clay	0	1		
Coal	0	3½		
Shale and coal	0	2½		
Coal	0	3½		
			1	7
Strata; chiefly flaggy sandstone and arenaceous shale..			20	6
COAL			0	6
g Underclay and argillaceous shale, with erect trees and *Stigmaria*			8	7
COAL			0	6
Strata			11	2
COAL			0	2
Strata; chiefly sandstone			82	3½
STONY SEAM.				
Coal, turning to black shale	1	0		
Black shale, coal and clay	0	6		
Coal, coarse and pyritous	1	0		
Shale	0	4		
Coal	0	2		
			3	0
Strata; chiefly underclay and carbonaceous shale			2	4
h SHELLY SEAM.				
Coal	0	4		
Clay	0	0½		
Coal or black shale	0	2		
Carbonaceous shale	0	6		
Coal resting on fossiliferous limestone	0	2½		
			1	3
Strata			57	0
COAL.				
Coal, coarse and pyritous	0	5		
Clay	0	1		
Coal, good	0	6		
			1	0
Strata; with irregular streaks and layers of coal			33	0½
COAL			0	10
Strata; chiefly sandstone, to Stubbart Point			38	2
Total thickness of strata			1671	10½
" " coal			41	9

Mr. Richard Brown, a most excellent authority, has assumed the base of the productive measures to be at this point; the underlying strata, consisting of an almost unbroken succession of beds of coarse grey sandstone, such as are characteristic of the Millstone Grit, with only one extremely irregular coal seam, at a depth of about 450 feet below Stubbart Point. In other parts of the field there are without doubt beds resembling those of the productive measures, and one workable coal seam (the Lorway or Gardiner seam) which, in stratigraphical position must underlie the point referred to; but as, in the Sydney mines section, such beds are exceedingly rare, I have in this and the following sections omitted all beds below the line determined by Mr. Brown, as the base of the productive measures. Certainly, the measures exposed in the sea cliffs, on either side of this point, although without any appearance of unconformity, exhibit very strikingly the change which has been noted and commented upon at page 195.

Base of the productive measures.

A few notes referring to the above section are subjoined:

Cranberry Head Lower seam.

(*a.*) *Cranberry Head Lower seam.*—Many erect *Sigillariæ* are seen overlying this seam, with trunks from two to three feet in diameter. One of these bends down the seam and forms an elevation in the overlying measures. The floor of the seam is very rich in *Stigmariæ*, which spread through the clay and over the sandstone in all directions, sometimes intertwining.

Lloyd Cove seam.

(*b.*) *Lloyd Cove seam.*—This seam after traversing the promontory near Cranberry Head, a distance of five-eighths of a mile, is cut off by the sea; but, being affected by the undulation in the measures caused by the Big Pond anticlinal, emerges again on land near Bonar Head, thence continuing its course north-westward parallel to and at a short distance from the shore line, with slight undulations, as far as Plant Point. Its section is nearly uniform throughout this entire distance until within fifteen chains of the Little Bras d'Or, where it splits into two seams by the gradual thickening of the clay band immediately underlying the upper bench of coal which, at the outcrop in the sea cliffs, is separated from the lower part of the seam by fourteen feet six inches of strata.

Chapel Point seams.

(*c.c.*) *Chapel Point seams.*—These seams crop out in the cliffs to the west of Cranberry Head at Black Point, a distance of a little more than a mile and a half from Chapel Point. Here they are considerably thicker and more important than at the latter place, and the thickness of the intervening strata is considerably reduced. The upper seam at Black Point contains two feet five inches of coal, and the lower, nearly two feet; the intervening strata being only twenty-one feet. At Oxford

Point, seven-eighths of a mile farther west, where they re-emerge from the sea, the upper seam is four feet, and the lower two feet six inches in thickness, separated by eighteen feet of shale.

Fossiliferous Limestone.

(*d.*) *Fossiliferous Limestone.*—Immediately underneath the thick bed of sandstone, which occurs towards the base of this part of the section, the first bed of fossiliferous limestone in the descending succession of the strata appears; after which such beds are numerous.

Sydney Main seam.

(*e.*) *Sydney Main seam.*—This highly important coal seam has been traced by numerous trial pits and boreholes throughout the entire district. It maintains its full size, as specified in the section, as far as Big Pond; but in tracing it thence to Little Bras d'Or, it is found, while still preserving its excellent quality, to diminish considerably in thickness. At Cox Hill, about three miles from the harbor, the seam was found on trial to be only three feet seven inches thick at the crop, and to diminish rapidly to the dip. Half a mile to the west of Cox Hill it is affected by a downthrow to the west, but only to the extent of a few feet. At a crop pit, three-quarters of a mile farther to the north-west, the seam is only two feet two inches, and at the shore of Little Bras d'Or, the same distance still farther in the same direction, it is three feet in thickness.

Indian Cove seam.

(*f.*) *Indian Cove or Number Three seam.*—This seam, with its equivalent in other parts of the field, is remarkably persistent and regular in thickness, although rather impure and sulphurous in quality. The section given above is that at the shore of Sydney Harbor: at a pit opened by the General Mining Association, about a mile to the westward, it is a little different, being as follows:—

	FT.	IN.
Coal and shale	0	3
Coal	0	4
Grey band	0	2
Coal	3	10
	4	7

It has also been opened a mile farther west, by several shallow pits, where the following section is exposed:—

	FT.	IN.
Coal	1	1
Band	0	3½
Coal	0	5½
Band	0	2½
Coal	1	11½
	4	0

Near the shore of the Little Bras d'Or, the same seam has also been worked to a small extent near the crop at Edwards', Laffin's, and Young's pits, where it has this section:—

	FT.	IN.
Coal	2	4
Band	0	4½
Coal	2	7
	5	3½[*]

(*g.*) It is at this point in the section that the remarkable phenomenon of the splitting of a coal seam, apparently by the gradual growth of the roots of a tree embedded in it, is displayed. (See page 203.)

Fossiliferous Limestones.

(*h.*) *Fossiliferous Limestones.*—Up to this point, the thin fossiliferous limestone beds occur in considerable profusion, but below it no trace of such beds is to be found.

The section at Little Bras d'Or is only partially exposed, so as to be capable of direct measurement; the banks of that channel being for the most part low and flat, especially throughout the south or lower half of the section. From Plant Point, the promontory at the eastern side of the channel, to the outcrop of the Sydney main seam, the strata may be measured with tolerable certainty; the rest of the section is for the most part only estimated.

SECTION XVII.

SYDNEY HARBOR BASIN. PLANT POINT TO LITTLE BRAS D'OR BRIDGE.

Dip North, 60° *East*, $< 5°$.

	FEET.	IN.	FEET.	IN.
Strata; thick bedded sandstone, forming Plant Point			21	2
LLOYD COVE UPPER SEAM.				
Coal, sulphurous, with a clay parting			2	7
Strata, underclay and sandstone			14	6
LLOYD COVE LOWER SEAM.				
Coal	0	2		
Clay, 4 to 10 inches, say	0	7		
Coal, with clay parting	1	7		
Clay	0	2		
Coal, with pyritous bands	4	0		
			6	6

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[*] For the three sections of the Indian Cove seam introduced here, I am indebted to Mr. Rutherford's Essay on the Coal Fields of Nova Scotia, page 46.

	FEET.	IN.	FEET.	IN.
Strata; for the most part estimated			231	7
COAL			1	0
Underclay			3	0
COAL			0	2
a Strata; chiefly sandstone, and several concealed intervals			257	10
COAL, at the mouth of Kidd Creek			0	4
Strata; much red, green and black shale, with *Naiadites*			122	5
SYDNEY MAIN SEAM:				
Coal			3	0
Strata			205	0
BRYANT SEAM:				
Coal, thickness unknown			2	0
Strata			78	0
COAL, thickness unknown			1	6
Strata			80	0
EDWARDS SEAM:				
Coal	2	4½		
Clay	0	4½		
Coal	2	7½		
			5	4½
Strata				
THREE FEET SEAM:				
Coal			3	0
COLLINS SEAM:				
Top coal	2	7¾		
Good coal	2	4		
			4	11¾
Strata; with probably two small coal seams			131	8
Total thickness of strata			1175	7¼
" " coal			29	3¾

Coal seams below the assumed base of the productive measures.

Beneath the point which, following the determination made on the east side of the district, has been assumed as the base of the productive measures, a few other coal seams are reported to exist, one of which is said to be five feet in thickness. But (with the exception of an eighteen inch seam which crops out a short distance above the bridge, and may be the equivalent of the Ingraham seam), I have failed to authenticate the reports regarding them.

(*a*.) In the above section no account appears of the Chapel Point seams of the harbor section; which, as we have seen, in tracing them westward, tend to come together, and to increase in thickness and importance. This is the more remarkable as, on the western side of the Little Bras d'Or, a very thick and fine seam occurs, which, I consider, must represent these seams compressed into one. Their apparent absence on the eastern side may be due to a large area of low ground occurring where their outcrop might be looked for, and to the accidental failure of the attempts hitherto made to find them by boring. There can be no doubt of their existence in some of these concealed intervals; and, consequently, the aggregate thickness of coal in the above section may fairly be augmented by about five feet.

Collieries in the Sydney Mines district.

Collieries in the Sydney Mines District.—Of these, as I have formerly had occasion to remark, by far the most important is the Sydney mines; a detailed description of which is given in the Report for 1872-73, pp. 242 to 248. The new shafts there mentioned were successfully completed in November last; and the coal was reached at a depth of six hundred and eighty-one feet from the surface, and found to be of the same thickness and quality as at the Queen pit workings. The arrangements for draining the mine and raising the coal at the New Winning, the branch railway to connect it with the harbor at North Sydney, and a new wharf, are nearly completed, and a very large addition to the output of the mine can now be commanded. The new wharf will be 500 feet in length, with greatly increased and improved facilities for loading, and with sufficient depth of water to accommodate the largest class of vessels. At the New Winning, thirty-two double or tenement houses for the miners have also been erected.

Works at Cox Hill.

The works of the General Mining Association, on the main seam at Cox Hill, were chiefly of an exploratory character. Besides a series of borings, a shaft was sunk to the depth of seventy-four feet; but as the seam at this point was found to be comparatively thin, and the measures disturbed, these works were abandoned. A branch railway from the main line from the Queen pit to North Sydney was nearly completed as far as Cox Hill. It was designed to form part of a line to open up collieries, if required, on the Company's property in Boulardrie Island, but has never been brought into use, and the works have been allowed to fall into decay.

No other collieries of importance have hitherto been established in the Sydney mines district, nor have any of the other seams been systematically or continuously worked. In a few instances, however, they have been opened on a small scale, with a view to the exportation of the coal, and crop pits for the supply of the neighbouring farmers are numerous, but undeserving of special notice.

Work on the Lloyd Cove seam.

The Lloyd Cove seam was opened ten or twelve years ago by the Association, by a slope from the crop, and a level driven from the shore. The slope is situated a little over half a mile to the east of the Queen pit, and extends to the water level at the shore, with which it is connected, and by which the mine is drained. From the foot of the slope a pair of drifts have been driven 200 yards to the dip, and a level extended to the north 350 yards. These works were discontinued in 1867, owing to the somewhat inferior quality of the seam, and because the colliery established on the main seam could supply all the demand. I have no record of the quantity of coal extracted at this point.

Work on the Indian Cove seam.

On the Indian Cove or Number Three seam, the General Mining Association have also opened a colliery, about a mile to the west of Indian Cove, but this also was abandoned several years ago, for the reasons just given. I have been unable to obtain any precise information as to the extent of the works at No. 3 Pit, or any statistics of its production. The shaft cuts the seam at 260 feet from the surface, which is eighty-nine feet above the level of the sea, and I understand that a very considerable quantity of coal was obtained at this place.

Works by Messrs. Roach & McInnis.

About one mile farther to the westward, and a little outside the Association's boundary line, works were established on the same seam by Messrs. Roach and McInnis, and were subsequently continued by Mr. Ingraham, of North Sydney. Here the seam is four feet thick and the principal shaft only twenty-five feet deep; there is also a slope from the crop about fifty yards in length, and several smaller openings. This colliery has been very little worked and the amount of coal extracted is inconsiderable. Operations were suspended in 1868, and were not resumed till late last autumn, when a little coal was extracted.

Between this place and the pits opened in the vicinity of the Little Bras d'Or (Edwards, Laffin's, &c.), a distance of two miles, no other openings have been made on this seam, so far as I am aware. At the latter point the seam is improved both in thickness and quality. The section is given at page 237; and an analysis by Professor Chapman of Toronto, of a sample from the Edwards pit, is as follows:

Moisture	1·82
Volatile, combustible matter	34·94
Fixed carbon	56·97
Sulphur, not determined	—
Ash	6·27
	100·00

The Collins Mine.

The Collins mine (sometimes called the Little Bras d'Or mine, has been opened, on a seam which is believed on good grounds to be the equivalent of the Stony seam of the Sydney mines section, but in a greatly improved condition, as regards both thickness and quality. It is situated on the south-eastern shore of the Little Bras d'Or, about four miles from the sea, and half a mile below the new bridge at Howley's Ferry. It was first opened by the General Mining Association in 1833, by a level from the water's edge, and was worked by them, on a small scale, for three or four years. Being, however, outside the limits of the Association's property, as subsequently determined, it was abandoned by them after yielding about 9,000 tons of coal; and has been intermittently worked by other parties till the year 1868, during the greater part of which time the sales of coal have averaged, according to Mr. Brown, 4,250 tons per annum.

Analys by Professor Chapman.

The seam, although somewhat irregular in thickness, may be said to average five feet throughout the workings. Professor Chapman visited this mine in 1873. He gives the coal an excellent character in every respect. The following is his analysis of it:—

Moisture	1·63
Volatile combustible matter	35·12
Fixed carbon	57·19
Sulphur	trace
Ash	6·06
	100.00

The dip of the seam is N. 71° E. <6°. It was worked from the crop by a slope connected with an adit running in from the shore; the slope is situated about 420 yards from the outcrop at the water level on Little Bras d'Or. A shaft ninety feet deep has been sunk 220 yards north-east of the slope and considerably to the dip of the seam. It has been connected underground with the other workings, but has never been used.

Shaft.

Wharf.

A wharf, suitable for vessels of light draught, has been constructed only 250 yards from the slope and connected with it by a tramway. From the facilities thus afforded for raising and shipping the coal, it seems reasonable to believe that under ordinary circumstances this colliery might be worked with considerable profit. provided the seam retains the thickness it has in the existing workings. During the current year the mine has I understand been reopened by a Toronto company with larger capital, under the management of Mr. S. N. Robinson. A new slope has been driven N. 47° E., a considerable distance below the old water level, from a point 130 yards from the wharf; and some coal shipped.

BRAS D'OR BASIN.

A little to the west of the Little Bras d'Or, a low, broad anticlinal, running from Point Aconi to Saunders Cove, deflects the strata to the south, to form the Bras d'Or basin, which includes on opposite sides, the Boulardrie and Cape Dauphin districts.

upposed fault.

It has been held by Brown, Hind, and others, that the Little Bras d'Or runs approximately on the line of a fault; and Professor Hind, reasoning from some assumed correspondence of certain of the coal seams in the Boulardrie district with others at Victoria mines, has even specified the direction and amount of the supposed fault, making it an upthrow to the north of 400 feet. On careful examination, I can find no evidence of such a fault, nor any break in the continuity of the coal seams, some of which, from the circumstance of their strike coinciding for considerable distances with the bends of the channel, have their outcrops on either side more or less remote from each other, thus, perhaps, suggesting the idea of a fault. The existence of the channel itself and its peculiar configuration, with precipitous rock cliffs on each side for a great part of its length, might seem to confirm the idea referred to; but there can be little doubt that these features are due entirely to denudation.

Boulardrie district.

Boulardrie District.—This district, for the most part held under lease by the General Mining Association, is separated on the west from the Sydney mines district only by the deep, winding channel of the Little Bras d'Or, nowhere more than a hundred yards wide. It comprises the north-eastern extremity of Boulardrie Island, and is a triangle, the base of which is the south line of the Association's lease; and extends from the Great to the Little Bras d'Or, a distance of rather more than five miles. The apex of the triangle, Point Aconi, is about the same distance north, and the extent of the area is about twelve square miles, underlaid by the entire thickness of the productive coal measures of Cape Breton, including some very important seams of coal.

Although enough has been ascertained, by an examination of the outcrops of the various coal seams, to establish the structure, any section which I might give of the measures on the west side of this channel would necessarily be very imperfect, owing to the want of good exposures; nor is it necessary, seeing that it would be for the most part a repetition of the former, or forestalling of the next succeeding section.

A few remarks may, however, here be made with respect to the relations of the seams on the opposite sides of the channel.

1. The Cranberry Head seams of the Sydney mines section, one or both, are represented, in the Boulardrie district, by the *Point Aconi seam*, which has a run of only twelve chains on land, traversing, near its extremity, the long narrow neck terminating at Point Aconi. Point Aconi seam.

2. The Lloyd Cove seam, which, as we have seen, is split near its outcrop on the eastern side of the Little Bras d'Or, appears to maintain approximately the same conditions on the western side in the Boulardrie district, where it is represented by the *Upper and Lower Bonar seams*, nearly the same distance apart, but improved in thickness and quality. Upper and Lower Bonar seams.

3. *The Stubbart seam*, a fine seam of coal, about eight feet in thickness occupies the place, and is doubtless the equivalent of the Chapel Point seams of the Sydney mines section, although, as already remarked, its precise position has not been ascertained on the east bank of the Little Bras d'Or. Stubbart seam.

4. The Sydney main seam, which, on the east bank, is only three feet thick, has its equivalent on the opposite side of the entrance, in the *Crawley seam*, which, in a pit, fifteen chains distant from the bank, and seventeen feet deep, sunk by the Association, has the following section:— Crawley seam.

	FEET.	IN.
Top coal	0	4
Clay	0	4
Coal; good,	1	10
Clay	0	4
Coal; good	2	0
	4	10

About half a mile north-west of this shaft, several crop pits have been sunk on this seam by the neighboring farmers. Here it shows:

	FEET.	IN.
Coal	3	6
Clay	0	6
Coal	4	0
	8	0

5. The seam which I have denominated *Bryant's*, is cut in a shaft tweuty-two feet deep, close to the west bank, where it is reported to be two feet six inches thick. I am not aware that any attempt has been made to trace this seam inland. Bryant's seam.

Edwards seam.

6. The *Edwards*, or Number Three seam of the Sydney mines district reappears on the opposite side of the channel, somewhat reduced in thickness, but with its characteristic *Naiadites* shale roof, by which it is easily identified throughout the entire coal field. It has been opened by an adit, close to the west bank on the land of John Marsh; here it is two feet nine inches thick. Half a mile further west, on the land of Dennis Sullivan, where it has been opened at a few points, it shows:—

	FEET.	IN.
Coal	3	6
Clay	0	4
Coal	0	4
	4	2

Again, at a further distance of half a mile west, on the land of Pierre Pierrot, the seam crops out in a brook, and is reduced in size, being only two feet eight inches thick.

Three feet seam.

7. The so-called Three Feet seam, overlying the Collins on the east side, is assumed to have its outcrop in the west bank at the Matheson mine, where the seam was nearly four feet thick at the shore, but only two feet nine inches, further inland.

Matheson seam.

8. There are some reasons, however, for believing that the Collins and Matheson seams are identical. Mr. William Campbell gives the following section as measured in the bank, and in a borehole at the Matheson mine.

	FEET.	IN.
MATHESON SEAM:	2	9
Strata	40	0
COAL	1	2
Strata	22	0
COAL	0	9
Strata	42	0
COAL, thin, with a clay parting in the middle	—	—
	108	8

Unless the Matheson here represents the Collins seam, the latter must be that found forty feet lower in the section.

Two feet seam.

9. A seam two feet thick, in a brook thirty-two chains north-west of the new bridge at Howley's Ferry, and probably the continuation of the eighteen inch seam on the opposite side has, however, a rather anomalous attitude, namely dip E. 10° S. $< 8°$; but this is probably only local and accidental. Below this point, on the west bank of the Little Bras d'Or, I have been unable to find any undoubted traces of a coal seam.

Section on Boulardrie Island.

On the north-west side of Boulardrie Island, the whole of the Coal Measures are exposed in an unbroken section, extending over a distance of about six miles, from Point Aconi to the Millstone Grit, and for the most part approximately in the direction of the dip. I have carefully measured this section, and the following is an abstract of it, full details being given elsewhere.

SECTION XVIII.

BOULARDRIE DISTRICT. POINT ACONI TO THE MILLSTONE GRIT.

Dip, North 50° East < 3° to North 16° West < 10°.

	FEET.	IN.	FEET.	IN.
Strata; chiefly sandstone and arenaceous shale			46	1
COAL			0	1½
Argillaceous shale, with coal in streaks			1	11
POINT ACONI SEAM:				
Coal			3	2
Strata; much red and green marl, and calcareous sandstone			206	5
COAL, good			0	7
Strata; underclay and argillaceous shale			6	7
COAL:				
Coal	0	2		
Clay	0	4		
Coal; impure and mixed	1	4		
Clay	0	2		
			2	0
Strata			16	3
BONAR UPPER SEAM:				
Coal, bright and clear; no partings			2	5
Strata			7	6
COAL			0	2
Strata, much carbonaceous shale			2	5½
BONAR LOWER SEAM:				
Coal	1	4		
Clay	0	0½		
Coal	3	0		
			4	4½
Strata, with several massive sandstone beds			162	6
COAL, irregular, averaging			0	5
Strata			20	7½
COAL:				
Coal	0	1		
Coal and clay	0	1		
Coal	0	3		
			0	5

	FEET.	IN.	FEET.	IN.
Strata; much calcareo-bituminous shale with coprolites, &c.			34	9
STUBBART SEAM:				
Coal	2	0		
Clay	0	1½		
Coal	0	3		
Clay	0	1½		
Coal	5	0		
			7	6
Strata, underclay			0	10
COAL			0	1
Strata, concealed			24	1
COAL			1	0
Strata; argillaceous shale			12	0
COAL			0	6
Strata; underclay and argillaceous shale			7	6
COAL			0	0¼
Strata, partially concealed at Battleman Bay; *Naiadites* shale at the base			236	7½
COAL			0	0½
Strata, mostly concealed at the Millpond outlet			40	6
COAL			0	6
Underclay and argillaceous shale			4	5
COAL			0	1
Strata; chiefly a thick bed of micaceous sandstone			42	0
COAL			0	7
Strata; chiefly sandstone as before			42	6
COAL:				
Coal, coarse	0	4		
Coal, good	0	6		
Underclay with coal streaks	0	6		
Coal, large erect tree	0	4		
			1	8
Probably, together with the next underlying seam, represents the SYDNEY MAIN SEAM.				
Underclay, &c			6	8
COAL:				
Coal	0	7½		
Clay	0	1		
Coal	0	4½		
			1	1
Underclay and argillaceous shale			4	2
COAL			0	1
Strata			28	5
COAL			0	5

	FEET.	IN.	FEET.	IN.
Strata; chiefly red and green marl			96	4
COAL, impure and mixed with stone			1	0
Strata			46	2½
COAL, good			0	10½
Strata			15	6
COAL			0	8
Strata			19	0
MILLPOND SEAM:				
Coal, good	2	4		
Clay	0	11		
Coal, fair	0	8		
			3	11
Strata			35	6
COAL			0	0½
Strata			19	8
COAL:				
Coal	0	8		
Clay	0	1		
Coal, pyritous, variable in thickness	0	9		
			1	6
Underclay and carbonaceous shale			0	10½
COAL			0	3
Strata			57	8
COAL, impure			0	4
Strata, with beds of limestone and *Naiadites* shale at the base			60	6½
BLACKROCK SEAM:				
Coal, bad	0	3		
Coal, pyritous	2	9		
			3	0
Strata, with large erect tree			21	11
COAL			0	1½
Strata			17	9
COAL			0	8
Strata			85	2½
COAL (F.), sulphurous			0	8
Strata			37	1
Coal and clay in four bands			0	9½
Argillaceous and carbonaceous shale			3	5
COAL			0	2½
Argillaceous and carbonaceous shale			2	3½
COAL (G.) and carbonaceous shale			0	11
Strata			39	1
COAL			0	2
Strata			9	1
Total thickness of strata			1567	3¼
Do do coal			38	11¼

Base of the productive measures.

The lower limit of the productive measures has been assumed at a point where sandstones prevail, to the almost total exclusion of argillaceous strata. Two other seams of coal are noted beneath the point where this section terminates; one four inches thick, about 200 feet, and the other fifteen inches thick, about 350 * feet below the point referred to. The latter may probably be the continuation of the Ingraham seam of the Sydney mines section, which, however, has nowhere been found in workable condition.

The Millpond.

Fault.

With the exception of the Stubbart seam, which has been traced continuously by various openings (maintaining its full thickness throughout), the coal seams in the Boulardrie district are very little developed, either by explorations or by actual working. There can be no doubt, however, that they extend uninterruptedly across the entire island. About three quarters of a mile east of the Great Bras d'Or, and running nearly parallel with its shore, there is a long channel or lagoon, called the Millpond, of an average width of 120 yards, extending about a mile and a half into the interior, and terminating in a brook. Some of the seams are exposed in the banks of this channel, and in such a manner as to prove the existence of a small fault running through it longitudinally. This fault is an upthrow to the west, but its amount cannot exceed a few feet. Near the outlet of the Millpond, where the measures appear to be troubled, several small coal seams crop out, which probably represent the Sydney main or Crawley seam, here entirely divested, although it may be only locally, of the important character it possesses elsewhere. On the other hand, a mile further up, a seam called the Millpond seam is exposed in the banks on both sides of the channel; this, according to my determination, must be the continuation of the Bryant seam which, at Little Bras d'Or is scarcely workable, but on the right bank of the Millpond is a fine seam four feet in thickness, and on the opposite side two feet ten inches. The same seam, as will be seen in the section, is four feet thick at the shore of the Great Bras d'Or, but is contaminated with a thick band of clay. The Blackrock or Number Three seam also crops out in the Millpond brook about half a mile further up.

Four feet seam.

No collieries worthy of the name have, as yet, been established in the Boulardrie district. On the Stubbart and Crawley seams, at Little Bras d'Or, and in that first named, at Morrison Pond, on the Atlantic side of the district, a considerable amount of coal has been taken out near

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* There is no possibility here of observing the thickness and succession of the strata.

the crop, partly by the General Mining Association, and partly by the country people. From the Millpond and Blackrock seams, on Great Bras d'Or, a little coal has been extracted by levels driven from the shore; but no regular mining has been attempted, the want of a port of shipment being one serious obstacle. The Campbell, or Matheson Mine, on Little Bras d'Or has been somewhat more systematically worked, having been in operation, on a limited scale, for about five years, terminating in 1868, when, owing to the limited amount of coal on the area, it was abandoned. During this period the shipments of coal only averaged 800 tons a year.

Campbell or Matheson Mine.

Cape Dauphin District.—The peculiar features characterizing this small district, which forms the north-western extremity of the coal field, have been adverted to on former occasions, and a detailed account of the New Campbellton colliery, which is situated in this district, has been given in the Report for 1873-74, pages 184-186 (See also the same Report, page 174; and that for 1870-71, page 4). The geological structure of this part of the field is so unique and remarkable, and the attitude and condition of the small portion of the productive measures developed upon it are so intimately connected with those of the underlying rocks, that I propose to describe and discuss the whole in a connected form. I shall, therefore, here merely state such facts as may be necessary, in order to illustrate the relations of the coal seams on that tract to those last described.

Cape Dauphin District.

The Great Bras d'Or, at its entrance, is a deep, funnel-shaped channel, being at its outer extremity, between Table Head and Cape Dauphin, two and a half miles in width, narrowing to twenty-eight and a half chains, at McNeil's Ferry, three miles further up the channel. As in the case of the other bays and inlets in this region, no break in the continuity of the measures is observable, the opposite shores being, as at Sydney Harbor, the sides of a basin, of which the greater part has been denuded.

Only the lower part of the productive measures, probably as far as the horizon of the Sydney main seam, is developed in this basin.* The section will be given in the sequel in connection with that of the underlying measures.

The seam principally worked at the New Campbellton mine, is undoubtedly the continuation of the Blackrock or Number Three seam of the Sydney mines section, and that underlying, which has been cut in a vertical attitude in the tunnel, is the equivalent of the Collins seam on Little Bras d'Or. The only seam of any importance which has yet been discovered overlying the four feet seam worked at the slope, is one of one foot eight inches in thickness, which may probably be identical with the Millpond seam. In the Millstone Grit at this place, is also found a coal seam of about the same thickness as that last named, which probably is the continuation of the Ingraham seam.

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* Although it is probable that the section at the New Campbellton mine embraces this seam, it cannot reasonably be expected to be workable; as, even although it might be in better condition than it is found to be on the opposite side of the Bras d'Or, it would still be too near the surface, and the strata too nearly horizontal to be available.

Coal seams in the Millstone Grit.

TABULAR VIEW OF THE EQUIVALENCY OF THE SEAMS.

With these explanations, and having now arrived at the western termination of the coal field, I propose to recapitulate, in tabular form, the enumeration and equivalency or identity of the more important coal seams in the productive measures throughout the whole region, arranged in the several districts, under the names by which they are locally known, and by distinguishing letters corresponding with those in the various sections. This Table (annexed) shows, also, the aggregate thickness of strata between the coal seams in each of the sections.

In thus identifying the coal seams, and assigning to them their respective positions in the measures, I am aware that I differ in some important points from others; but I feel confident that the determinations, having been made after a more laborious and comprehensive observation and study of all the facts than had been hitherto given to them, will be found, in the main, correct.

Difficulty in identifying the seams in the Millstone Grit.

There is so much uncertainty in regard to the identity of the seams in the Millstone Grit, that it is to be feared no satisfactory result could be arrived at by attempting to include them in the Table.

It will be seen by the sheet of grouped sections—which embodies the same information as the Table, in a different form—that by placing on the same level the main seam of the Sydney mines, and its equivalents throughout the field, which are the most eligible as a point of departure, all the other seams range approximately on the same horizon, the difference not being greater than we find in many instances where the identity of the beds is indisputable.

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in.	SYDNEY HARBOR. Section XV.	Strata and Coal. Ft.	in.
0			
2			
5	Paint		
1			
1	Crandall, &c........		
3			
0	Victoria		
0			
0	Willie Frazer.......	1	8
1		37	0
0	Number Three......	4	0
1		53	3
0	H. McGilvary	1	9
3		54	0
6	D. McGilvary	6	0
5			
0	Seam H............		
0	....	13	5

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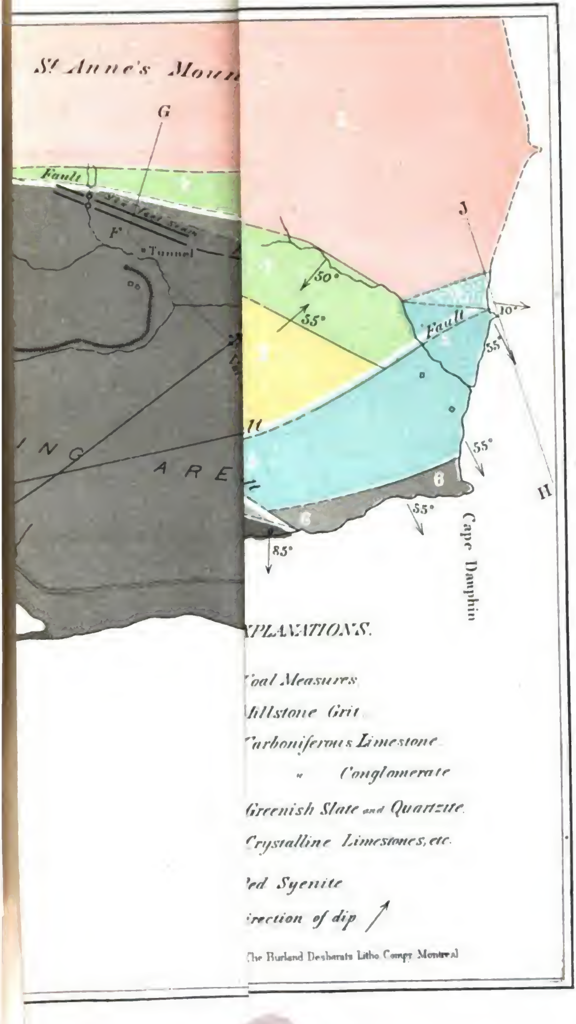
Coal seam
the Millst
Grit.

Difficulty
identifyi
seams in
Millstone



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CAPE DAUPHIN DISTRICT.

This district has been minutely and carefully surveyed; and I propose now to give the results, referring in illustration to the map herewith presented, drawn to a scale of four inches to a mile.

St. Anne's Harbor.

It is not more than four miles in length, by about one mile wide; situated between the western shore of the Great Bras d'Or and the high ridge of St. Anne's Mountain, which separates it from St. Anne's Harbor. The general physical features have been described in previous reports;* the most notable being the abrupt transition from a gently-rolling and comparatively level country, underlaid by carboniferous rocks, into a high and steep mountain range, whose naked and precipitous cliffs of red syenite are fringed by a heavy talus.

It has already been remarked that the best means of determining the structure of a coal field is to trace the coal seams; and, fortunately, the mining and exploratory operations at New Campbellton have been on a sufficiently extensive scale to give much assistance in this respect. The natural sections, also, afforded in the sea cliffs at either end of the area, and the gorges cutting transversely the lines of junction of the various rock formations at numerous intermediate points, leave little to be desired in determining their mutual relations.

Carboniferous limestone.

The general direction of the mountain range and the axis of the carboniferous basin at this place is N. 35° E. At the southern end of the area, the Millstone Grit is represented by a mass of coarse, grey, irregularly-bedded sandstone, about 1,800 feet in thickness; dipping to the east at angles varying from 12° to 40°. The lower part of the productive measures only, to the extent represented in the sections,† is developed in this area. The Millstone Grit is underlaid at Kelly Cove by a small patch of Carboniferous Limestone, consisting of the usual alternations of red marl and fossiliferous limestone. The thickness at this place is doubtful, the greater part of the measures having been swept away; it is probably about 1,000 feet in all. There appears to be no want of conformity between it and the Millstone Grit; but, on approaching the mountain, we find the whole of the carboniferous rocks abruptly cut off and thrown into an attitude for the most part vertical, and occasionally overturned. At some points these rocks are brought into con-

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* Reports of Progress for 1871, pages 4 and 5; for 1873-74, pages 174-175, 184-185; and for 1874-75.

† See Section XXI.; also the sheet and table of grouped sections.

Metamorphic rocks, calcites, argillites and quartzites.

tact with the syenite; but, generally, there is interposed a varying thickness of metamorphic calcites, argillites and quartzites, associated with dolomites and other magnesian rocks; also in a vertical or highly inclined position, and evidently belonging to a pre-carboniferous series of altered sedimentary rocks, the age of which, in the absence of fossils, can only be inferred on lithological evidence.

At Kelly Cove, where these rocks attain their greatest development towards the south end of the area, and are cut by the coast line of the Great Bras d'Or, the following descending section is shown, the dip being east, at angles increasing gradually from 45° at the top to 75° at the bottom. The overlying carboniferous rocks, as far as the top of the Millstone Grit, are included in the section.

SECTION XIX. (on the line A B.)

NEW CAMPBELLTON WHARF TO ST. ANNE'S MOUNTAIN.

Dip East < 45° to 75°.

Pre-Carboniferous rocks.

	FEET.	IN.	FEET.	IN.
MILLSTONE GRIT			1,800	0
CARBONIFEROUS LIMESTONE:				
Measures concealed; probably for the most part soft marls. Dip E. < 45°	707	0		
Compact grey fossiliferous limestone, full of geodes lined with calcspar and bristling with dog-tooth spar	88	0		
Slaty limestone	24	6		
Green and red marl	11	4		
Yellow-weathering, slaty, arenaceous limestone	8	2		
Measures concealed	40	9		
Limestone and red marl	13	2		
Measures concealed	6	4		
Fine-grained limestone	8	0		
Measures concealed	6	4		
Limestone, undetermined; probably about	6	0		
Measures concealed	7	7		
Compact limestone	15	10		
Nodular limestone	24	3		
Brown, coarse, granular, fetid limestone	17	6		
Black, hard, cherty limestone. Dip E. < 70°	17	0		
			1,001	9
PRE-CARBONIFEROUS ROCKS:				
Gnarled and contorted crystalline limestone, light blue, with streaks of white	14	3		
Blue and white argillaceous rock; calcareous in places	53	8		

	FEET.	IN.	FEET.	IN.
Gnarled and contorted limestone, as before; in flaggy layers; forming a high cliff	8	1		
Hard cherty rocks; white-weathering highly calcareous rock, with greenish streaks. Alternations of chert, crystalline limestone and quartzite in thick beds. Dark-brown fine-grained diorite, with serpentinous coatings in the joints, and streaked or ribboned in a great variety of colors. Laminated, black and greenish, cherty rocks. Calcareous and magnesian rocks and quartzite with thin laminæ of crystalline limestone and steatite. Aggregate thickness, about	470	0		
			546	0
Red syenite of St. Anne's Mountain				

About fifty chains to the north-west, the metamorphic rocks entirely disappear, thinning off into a wedge-like form; and are capped by the Carboniferous Limestone, which is in immediate contact with the syenite; but they reappear in a similar manner a little farther to the north, where, however, the lower carboniferous rocks are entirely cut out. At a point about one and a quarter mile from Kelly Cove, where the metamorphic rocks are well exposed in a deep gorge, the following section was measured. The strata dip to the south-east at high angles, and in approaching the syenite, are vertical. The section includes, probably, the whole of the millstone grit rocks which come to the surface at this point.

Section of metamorphic rocks near Kelly Cove.

SECTION XX. (on the line D C.)

NEW CAMPBELLTON MINE TO ST. ANNE'S MOUNTAIN.

	FEET.	IN.	FEET.	IN.
MILLSTONE GRIT:				
Bluish-grey argillaceous shale, Dip N. 71°, E. < 29°				
Measures concealed, on dip estimated < 51°	233	0		
Fine-grained, brown, flaggy, sandstone, Dip N. 105°, E. < 75°	92	0		
Bluish-grey, argillaceous shale	25	0		
			350	0
PRE-CARBONIFEROUS ROCKS:				
Fine-grained, laminated dolomite, with calcspar coating the joints	12	0		
Compact, dolomitic limestone, stained lead-grey in the joints; contains specks of galena, iron and copper pyrites	13	0		
Laminated, contorted, sub-crystalline limestone	30	0		
White massive, broadly crystalline dolomite; weathering grey	144	0		
(For analysis, see Report for 1873-74, p. 174)				

	FEET.	IN.	FEET.	IN.
Laminated, white and blue streaked limestone, jointed, and with cleavage plains; calcspar in the joints	6	0		
Dark-blue, fine-grained diorite, with serpentinous coatings in the joints	0	10		
Greenish and white calcareo-magnesian quartzite...	1	2		
Strata, with much siliceous matter	0	7		
Dark-blue quartzite	0	9		
Talcose, or impure steatitic rock, with quartz laminæ.	4	0		
Greenish, friable, granular quartzite	1	4		
Blue quartzite	1	0		
Cream-colored quartzite	2	6		
(These quartzites are much cleaved, jointed and contorted, traversed by quartz veins, and very brittle; and have, consequently, been cut out into a glen; higher up, on the escarpment, they appear to be lost, and the calcareous rocks coalesce).				
Banded, bluish and white limestone	24	0		
Greenish-white, saccharoidal limestone	5	0		
Banded and streaked blue and white limestone	4	0		
(Small red syenite veins, in no case exceeding two inches in thickness, occur in the last two beds, running both in the bedding and cleavage planes, and sometimes intersecting both).				
Bluish, reddish, greenish, and white banded dolomite, with streaks of serpentine	4	0		
Dark-green serpentine	0	3		
Streaked, blue and white limestone, with druses containing Iceland and dogtooth spar	21	9		
Quartzite, grey or white, and vitreous; or bluish, with magnesian films in the joints; traversed irregularly by patches of red syenite. Syenite in one inch layers, interstratified with the quartzite, near its contact with the mass of syenite in the mountain. In some places banded, bluish quartzite and syenite, in layers of equal thickness, intervene between the limestone and syenite. The quartzite is frequently wanting; and the limestone, in such cases, comes in contact with the alternations of quartzite and syenite; and, in one instance, a layer of white calcite, half an inch thick, is embedded between two layers of the syenite at the point of contact. The quartzite contains specks of galena and iron pyrites	26	8		
			302	10

	FEET.	IN.
Red syenite, as above. No admixture of the foregoing rocks, except at the point of contact. For a considerable distance up the gorge, nothing but this red syenite is seen. The hills rise to an elevation of upwards of 1,000 feet, at no great distance from the Coal Measures; and the highest peak, 1,045 feet, is not more than 2,000 feet from the tunnel at the New Campbellton mine		

Towards their junction with the syenite the quartzites are highly pyritous; and when in contact, patches of the calcareous and magnesian rocks are found closely adhering to the syenite, which is also seen, in some places, to overlap and envelope them.

Coal Measures in contact with syenite.

About eighteen chains north from the point where the last section was obtained, the Coal Measures are brought into contact with the syenite, and a coal seam is actually exposed within seventy feet of the junction. The coal has undergone no alteration from heat, although much broken and slickensided.

The number, position and attitude of the coal seams throughout the whole area have been already specified and described in the notice of the New Campbellton colliery (Report for 1873-74, pages 184-185). They are also fully illustrated in the accompanying map and subjoined section, which was obtained partly in the tunnel and partly by measurement of the surface. In this section, the Millstone Grit is entirely wanting, and the productive measures are in contact with the metamorphic rocks.

SECTION XXI. (on the line E F.G.)

GREAT BRAS D'OR TO ST. ANNE'S MOUNTAIN.

	FEET.	IN.
COAL MEASURES:		
Red marl	2	0
Bluish, roughly laminated, splintry argillaceous rock............	12	0
Dark-blue argillaceous rock, streaked red; weathering into clay..	2	0
Bluish-grey, hard, argillaceous rock in flaggy layers, sometimes 18 in. thick, micaceous, and with ironstone nodules............	7	6
Dark-blue argillaceous shale..................................	6	0
[The above beds are seen on the shore lying horizontally.]		
Bluish grey sandstone; forming a reef and point................	8	0
Measures concealed..	300	0
Bluish-grey argillaceous shale................................	8	0
COAL (D) opened at McLennan's, near the brook; also supposed to be the seam found on the shore (mixed coal and clay 3 ft. 6 in.)	1	8

	FEET.	IN.
Underclay	2	0
Grey, black-streaked, false-bedded, coarse sandstone	15	0
Measures concealed	13	4
[From this point, the strata, which had previously dipped to the east at angles not exceeding fifteen degrees, suddenly, by reason of a fault, assume a vertical attitude; but it is believed that the continuity of the section remains unbroken.]		
Light-blue soft sandstone	17	6
COAL	0	9
Argillaceous and arenaceous shale, with fern impressions	16	9
COAL, good	1	9
Underclay, with *Stigmaria*	2	0
Hard grey sandstone	62	0
COAL and clay	3	0
Underclay, with *Stigmaria*	6	0
Hard grey sandstone	9	0
Dark blue, arenaceous shale	6	9
Light blue, hard sandstone	10	0
Argillaceous and bituminous shale	0	6
Dark-red, soft underclay	17	0
Grey massive sandstone	48	0
Light-blue, flaggy or laminated sandstone	3	0
Soft white fireclay	0	2
Very dark brown, calcareo-bituminous, corrugated shale, with *Naiadites*	2	6
FOUR FEET SEAM:		
Coal	4	0
Underclay, with *Stigmaria*	2	6
Light-blue sandstone	30	0
COAL	0	3
Fireclay	0	6
Light bluish-grey sandstone	20	0
COAL (F) of excellent quality	1	9
Underclay and dark-red arenaceous shale	11	3
Light-blue, flaggy or laminated sandstone	10	6
COAL	0	3
Light-blue sandstone	30	0
Argillaceous shale	2	0
SIX FEET SEAM:		
Coal	6	0
This seam appears to be extremely irregular, both in thickness and quality, and is sometimes pinched out entirely. Where worked in the level, south from the tunnel, the surface facing the mountain is much slickensided and ground to powder, as if from the effects of a slide, accompanied by great pressure.		
Underclay, with *Stigmaria*	4	0

	FEET.	IN.
Bluish-grey argillaceous shale, slickensided	20	0
Brown, fine-grained, argillaceous shale, with imperfect cleavage and jointing	10	0
Yellowish-grey sandstone, with many cleavage planes	43	0
	780	2
PRE-CARBONIFEROUS ROCKS:		
Bright green, calcareous clay or marl, mottled Indian red, or bright chocolate color; inclosing pieces of calcareous rock containing red hematite; small vugs filled with calcspar crystals Probably on a line of fault	0	6
Gnarled and contorted limestone	181	0
Similar rock, but hard, shaly, cleft and less calcareous	28	6
Laminated, slightly calcareous quartzites, dolomites and other magnesian rocks as specified in Sections XIX. and XX; aggregate thickness	47	6
	257	6
Syenite of St. Anne's Mountain		

Thickness of pre-carboniferous rocks.

Proceeding still farther north from the tunnel at the new Campbellton mine, the pre-carboniferous rocks reappear, at first in a band not exceeding 200 feet, but gradually increasing in thickness, until they attain a breadth of about 2,000 feet near Cape Dauphin. About two-thirds of this breadth, however, is here made up of a band of bluish-grey argillaceous slate and quartzite, without calcareous beds, interposed between the carboniferous rocks and the limestones. Although thus presenting such a marked difference in lithological character, both slates and limestones may belong to the same formation. The slates are highly ferruginous, weathering to a rusty brown color; generally very finely laminated, with smooth silky surfaces, but often of a compact structure; and at one place, near the southern end of the band, penetrated by a great quartz vein, which also partially cuts the limestones.

Quartz vein.

Junction of limestones and syenites.

The line of junction of the limestones with the syenite is approximately parallel to the general trend of the mountain range; but that of the carboniferous and pre-carboniferous rocks tends to follow the basin shape of the former, except when that is sharply cut off by the syenite, as before described, and as represented in the map.

The limestones and associated rocks, towards the northern end of the area, or in the vicinity of Cape Dauphin, cover the flank of the syenite mountain, to the height of at least 600 feet above the level of the sea.

The line of junction, although generally straight, is locally irregular; and in some instances, the limestones seem to fill depressions in the syenite. The carboniferous rocks, although much disturbed, are everywhere unaltered, and some of the beds are charged with characteristic fossils.

Faults.

A complication of faults occurs at Cape Dauphin, by which all the formations from the Coal Measures to the syenite, are brought into unconformable juxtaposition, as shown by the boundaries on the map.

Conglomerate resting on syenite.

At about fifty chains westward from the cape, lower carboniferous conglomerates rest directly on the syenite, generally filling hollows in the latter, and, in some cases, affected by minor faults in various directions.

Bedded or jointed structure of syenite.

The coast to the westward of this point, where the syenite, in high precipitous cliffs, plunges into the deep waters of the Atlantic Ocean, was not closely examined or measured. Here the syenite assumes a bedded structure (which appearance, however, may be due to jointing), with dips at a high and uniform angle to the east; and many bands of a darker colored, closer grained, calcareous rock, resembling an altered sandstone, appear as if interstratified with it. Some of these, however, are seen to thin out and terminate before coming to the water level, and it is difficult to determine whether they belong to the sub-crystalline calcareous rocks, more extensively developed to the eastward, or more directly to the syenite mass itself.

Rocks derived from syenite.

The lower carboniferous rocks, which immediately overlie the syenite at this place, consist, where seen, of a conglomerate, or rather breccia, of a prevailing red tint, red sandstone, red and green marl, and limestone holding marine fossils characteristic of the formation referred to. The materials of which they are composed (with the exception of the limestone, which is probably for the most part of organic origin), are evidently derived from the disintegration of the syenite, limestone and quartzite immediately underlying. The pebbles of the breccia are frequenty large and angular; and some of the sandstone beds, where seen in actual contact with the syenite, are entirely made up of fine fragments of the latter. The conglomerate, at its contact with the syenite, is nearly horizontal; but the continuity of the beds is broken by small faults, which occur along the lines where the altered sandstones are in contact with the syenite. In one instance these strata seem to be actually inverted; and a thick bed of carboniferous limestone, resembling that which, in the immediate vicinity, overlies the sandstones, etc., is

Inversion of strata.

seen apparently to *underlie* these rocks, while still preserving an attitude approaching horizontality.*

A further illustration of this inversion of the strata is seen about a mile west from Cape Dauphin, on the sea shore, where a mass of carboniferous limestone, occupying a breadth of 250 yards, has been thrown down by a fault, the direction of which, on the west side, appears to coincide with the bedding or planes of jointing of the syenite, and of the faults before referred to, near the same place. The limestone is regularly stratified in beds of about three feet and upwards, and dips N. 25° E., < 20°. Its upper beds, containing for a thickness of about three feet many fragments of red syenite, are overlaid by a fine calcareous breccia of syenite fragments, capped by thin-bedded red and green mottled sandstone, indistinguishable from the lower carboniferous sandstones so largely developed on the shores of Sydney Harbor. This whole assemblage of beds is surmounted by the syenite, which rises abruptly into a bold beetling cliff.

Large caves

The limestone is worn by the action of the atmosphere, and by the waves, into numerous caverns of greater or less depth. Two caves of large size occur here, known as the Fairy Holes. One of these is about fifteen feet high and twenty feet wide at the entrance, which is only accessible (except by boat) at low tides. It ramifies in the interior into numerous long, narrow chambers, of sufficient size to admit a man in a stooping or crawling posture; but rapidly contracting. The arched roof is in some places scooped out of the conglomerate or breccia, and the cave ascends towards the interior, and then descends and branches into compartments. Large blocks of the limestone are strewn along the floor, mixed with white clay and soft earth. No water is met with, and the roof and sides are covered with a thin vegetable mould. No stalactites occur. A brook falls into the sea a few feet west of the opening; and from this the cave is approached at low tide, when the wind is off the shore.

In a deep, picturesque, wooded gorge, at the bottom of which flows a large brook, and about fifty yards to the west of the former, is a second cave, excavated in the same limestone, also near the shore. Although narrower and lower than the first, it is deeper, and, in some respects, more interesting. A small brook runs in the floor of this cavern, and water trickles copiously from the roof, leaving, by its evaporation, a great multitude of stalactites and stalagmites. At the entrance, and for a considerable distance into the interior, it has the dimensions of a small adit, and admits of a man walking upright. It then narrows rapidly until it becomes necessary to crawl, in order to explore the inner recesses. Again it widens; and one may proceed on hands and knees to a point at which the brook flows over a ledge, beyond which it would be impossible to go without dragging oneself through the ice-cold stream. There is no doubt that both these caves owe their origin to the decomposing effect of air and water, penetrating fissures, originally very small, in the limestone. Such caves, frequently holding strong streams of limpid water, are everywhere characteristic of the Carboniferous Limestone.

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* Similar facts, in relation to the syenitic range and associated rocks of the Malvern Hills, in England, where the conditions bear considerable resemblance to those above described, were noted by Mr. Leonard Horner, and have been described by him in the Geological Transactions of London, Vol. I., and attracted much attention from geologists at the time. See also the Memoirs of the Geological Survey of Great Britain.

Carboniferous rocks well exposed.

From the point in the coast line where the syenite first appears, for a distance of twenty-five chains eastward, the carboniferous rocks, as before remarked, are well exposed in regular successive beds, without faults, or disturbance of any kind, except such as are due to the general uptilting of the strata. The following is the section here, in descending order, commencing at the Millstone Grit, which forms Cape Dauphin and extends five chains to the westward.

Section.

SECTION XXII. (on the line H J.)

CAPE DAUPHIN TO ST. ANNE'S MOUNTAIN.

Dip North 75° *East* < 55°.

	FEET.	IN.
Bluish-grey, coarse sandstone, with drift plants; jointed; slickinsided on planes of bedding; irregular coaly matter and underclays. This represents the Millstone Grit	397	0
Bluish argillaceous shale, with nodular, grey and pink, slightly calcareous, fine grained rock	9	8
Purple and blue marl, with hard bands	12	2
Argillaceous shale, with plants	5	8
Hard calcareous rock, with thin white veins	5	0
Blue argillaceous shale, with many thin hard calcareous bands	20	0
Brown and grey shaly marl, with a little calcareous matter	18	0
Blue marl in alternate hard and soft beds	11	2
Hard grey limestone	0	4
Blue shaly marl, with occasional harder bands	19	4
Grey curly limestone, of irregular thickness	0	8
Alternating soft and hard argillaceous shale, traversed by calc-spar veins	12	10
Purplish marl	1	0
Calcareo-arenaceous shale	3	10

	FEET.	IN.
Argillaceous shale, in alternating hard and soft bands	34	10
Shaly, calcareous and micaceous sandstone	5	2
Alternations of marl and limestone, with imperfect lamination	30	3
Arenaceous shale	2	8
Nodular limestone, in thin beds, with interposed layers of arenaceous shale	13	6
Argillaceous marl (no lamination) with thin limestone beds, and a thin bed of carbonaceous shale	27	8
Massive, grey, fetid limestone	8	0
Fetid, calcareous sandstone	1	7
Limestone	11	3
Measures concealed ; probably soft marl	85	3
Massive limestone	19	4
Red and green marl	41	10
Compact and flaggy limestone	3	9
Nodular limestone	3	0
Carbonaceous shale	0	2
Calcareous sandstone	2	0
Dark blue, fetid, fossiliferous limestone	0	7
Calcareous sandstone	2	2
Red and green marl	41	5
Calcareous sandstone	29	2
Red and green marl	15	2
Bluish laminated limestone	4	0
Red and green marl	21	7
Concretionary limestone, sometimes massive	56	4
Greenish marl	39	7
Hard, blue, concretionary limestone	3	10
White gypsum	10	11
Measures concealed ; probably red marl	25	8
Concretionary limestone	4	6
White gypsum	5	2
Measures concealed ; probably red and green marl	43	5
Arenaceous, vesicular, fossiliferous limestone	3	10
Brown, friable, calcareous sandstone	3	10
Measures concealed ; probably red marl	16	10
Very hard conglomerate limestone	32	2
Green marl	3	10
Compact, vesicular, non-fossiliferous limestone	66	2
Soft brown earth	0	5
Compact, black, massive limestone, with veins of black chert	5	2
Green marl	1	0
Calcareous sandstone	0	1
Green marl	1	0
Brownish marl	5	2

	FEET.	IN.
Red and green marl	24	3
Reddish conglomerate, coarse at base, fine-grained above; pebbles of red syenite, brown, red and other colored metamorphic limestones; of great but unknown thickness	—	—
Reddish, calcareous rock	1	0
Green, slightly calcareous rock	1	0
Red syenite of St. Anne's Mountain	—	—
Total thickness (exclusive of conglomerate)	1,276	2

Section the same as that measured by Mr. R. Brown.

This section, although somewhat different, both in regard to the description of the individual beds and the total thickness observed, is the same as that measured in detail by Mr. Richard Brown, and described in the Journal of the Geological Society of London, Vol. III., page 257; and is also quoted from Mr. Brown, by Dr. Dawson, in his Acadian Geology, page 402–403.

Fault.

Basin shape of the carboniferous strata.

In the above section, the division between the Millstone Grit and lower carboniferous rocks is distinct, and most unequivocally marked, but there is no unconformity.. Between the Coal Measures and Millstone Grit, at Cape Dauphin, there is evidence of a fault, which is probably the continuation of that which exists between the carboniferous and metamorphic rocks. The dips observed in the Millstone Grit, at Cape Dauphin and at Bird Islands, which lie N. 30° E., a mile and a half distant from the cape, when compared with those in the same formation in the south part of the district, clearly indicate the basin shape of the carboniferous strata.

Economic Minerals.

The following economic minerals have been observed in this region:

Clay ironstones probably not of economic importance.

Clay Iron Stone.—Numerous beds occur in the Coal Measures containing argillaceous iron ore, both in nodules and in thin continuous bands. An average sample, analyzed by Dr. Harrington, yielded about 28 per cent. of metallic iron (Report for 1873-74, page 242). A great proportion of the iron made in Great Britain is derived from such ores, but there is not much hope of an adequate supply in Cape Breton for economic purposes; though considerable quantities of it are found strewn along the beach under the cliffs, from which it has been derived.

Schooner Pond.

Bog Iron Ore.—A deposit of this ore, apparently of excellent quality, was observed near Schooner Pond; but its extent appears to be limited. Such deposits will, no doubt, be found in many other places, as most of the springs issuing from rocks associated with the coal seams hold in solution a considerable proportion of iron, which, being precipitated, gives rise to the deposits of bog ore.

Deposits of hematite.

Hematite.—At or near the contact of the Lower Carboniferous with the underlying metamorphic rocks, veins or beds of hematite, of workable size and quality, have been discovered, and afford promise of being available for the manufacture of iron and steel. In one instance, at the Whykokomagh iron mine, described in the Report for 1873-74, page 180, considerable exploratory work has been done, but is, in the meantime, suspended. Near Big Pond, East Bay, Bras d'Or Lake, about twenty-two miles from Sydney, a deposit of ochreous red hematite, apparently of great extent, has recently been discovered, and a little exploratory work done upon it. A fair representative sample of the ore has been analyzed by Professor Henry How, of Windsor, N. S., with the following results:

Analysis by Professor How.

Siliceous gangue	8·78
Soluble silica	0·26
Peroxide of iron, with trace of alumina	88·21
Water	1·53
Magnesia	1·22
	100·00
Metallic iron, per cent	61·39
Sulphur	traces.
Phosphorus	minute traces.

In calculating the metallic iron, allowance is made for the trifling amount of alumina present. This ore is specially adapted for the manufacture of Bessemer pig iron.

Limestone.—The limestones which prevail extensively in the carboniferous limestone series, produce, when calcined, a good strong lime, but rather dark for the interior finishing of houses. An unlimited supply can be produced at a very cheap rate, as beds of considerable thickness crop out in immediate proximity to good harbors; slack or coarse coal for burning it can be obtained from the mines at almost a nominal price. Several kilns are in constant operation throughout the district for local supply, chiefly at the North-west Arm of Sydney Harbor.

Dark color of lime.

Kilns in operation.

Flags.—Some of the beds in the Millstone Grit produce excellent flags. They have been quarried to a limited extent on the beach near the South Bar on Sydney Harbor, where slabs of great strength and remarkably smooth and even, have been procured, measuring five or six feet across, and three to four inches in thickness. Some of the calcareous

Size of flags.

sandstones in the productive measures, appear, also, to be well adapted for flagging.

Grindstones.—Grindstones of fair quality are afforded by the sandstones of the Coal Measures, and are manufactured to a limited extent for local use.

Building Stones.—The sandstones, both of the Millstone Grit and Coal Measures, are generally too coarse, too irregular in the bedding, and too much impregnated with iron to yield good building materials, except for foundations and other rough work. Some of the upper beds of the carboniferous limestone formation, however, afford a dark red, brown, or chocolate-colored, very homogeneous sandstone, which would probably be more valuable as a building material. Such beds crop out at the water's edge, on Sydney Harbor, in the most advantageous position for working and shipping.

Sandstone suitable for building.

Syenite for ornamental purposes.

Syenite.—The syenite of St. Anne's Mountain, at Kelly Cove and Cape Dauphin, will be found admirably adapted for ornamental architecture. It possesses a great variety of beautiful tints, admirably blended, is capable of being extracted in blocks of any required dimensions, and is also very conveniently situated for shipping.

Marble.—At the same locality, white and variously tinted marbles can also be procured with great facility.

Gypsum.—The carboniferous limestone formation in Cape Breton is specially characterized by the occurrence of extensive deposits of gypsum; but in the districts to which this report has special reference, no deposits of this mineral, of economic importance, have been discovered. At North Sydney and at Cape Dauphin, gypsum beds of limited extent were observed, and are noted in the sections; others of greater extent were visited, but not specially examined.

Brick-clay and Fire-clay.—These materials are also available in the district; the former has been worked at the North-west Arm and other points, and the latter may be obtained in any required quantity, and probably of good quality, from the underclays of most of the coal seams. In some instances these are nearly pure white, and very free from iron and sulphur.

White clays.

SURFACE GEOLOGY.

Glacial action.

In the descriptions given of the geological and physical characteristics of this region, reference has been incidentally made to its surface features, and especially to the existence of numerous parallel bays and channels in the coast, as well as ridges in the interior, which are probably due to glacial action. This is indicated by their general direction being coincident with that of the glacial striæ, of which numerous reliable observations were obtained. The occurrence also, at the head of the North-west Arm of Sydney Harbor, of a great profusion of erratic boulders, consisting of granitic, felsitic and hornblendic rocks, probably derived from remote northern regions, and the manner of their distribution seem also to confirm this supposition. It is worthy of remark, that the distribution of the hard metamorphic rocks appears to have influenced the direction of the denuding agencies during the Glacial period. Thus it would seem that the entire area of Bras d'Or Lake has been excavated by glacial action in the soft marls and other friable rocks of the lower carboniferous formations, the remains of which now fringe its margin.

Erratics.

Excavation of Bras d'Or Lake.

Glacial striæ were observed at several points throughout the region, both on the highest crests of the ridges, and close to the sea level, but only on the millstone grit rocks. In some instances two sets were noted on the same smoothed surface, crossing each other at a small angle. The following are the localities and directions noted :

Glacial striæ.

Indian Cove, Sydney Harbor, north side, S. 61° W.

Victoria mines wharf, Sydney Harbor, south side, S. 54° W.

International wharf, Sydney Harbor, south side, S. 52° W.

Intermediate between the two last-named points, S. 53° W.

Cow Bay road, half way between Sydney and Cow Bay ; two sets crossing, S. 76° W. and S. 36° W.

Cow Bay road, one mile west of the last point, S. 54° W.

Cow Bay road, at the junction of the old Grand Lake road, S. 54° W.

Cow Bay road, Fitzpatrick Brook, five miles east of Sydney, S. 53° W., S. 59° W., S. 71° W., and S. 82° W.

Cow Bay road, Power Lake, four miles east of Sydney, S. 38° W., S. 46° W., S. 53° W., S. 60° W., S. 66° W. ; sometimes intersecting.

Grand Lake road, two and a half miles east of Sydney, two sets, S. 56° W. and S. 36° W.

Grand Lake road, three miles east of Sydney, S. 49° W, S. 58° W.

Lingan road, four and a half miles east of Sydney, S. 46° W.

Little Bras d'Or, on road to North Sydney, W. 26° N.

Although, as already mentioned, erratic boulders of foreign origin are not altogether wanting in this region, they are comparatively scarce ; the loose rocks on the surface being, for the most part, derived from the beds immediately underlying. The soil also appears to be of similar origin, generally very poor and thin, as is usual in regions occupied by sandstone. Where the red marls and other calcareous rocks of the Carboniferous Limestone occur, the soil is always richer, as shown by the superior character of the vegetation.

Scarcity of erratics.

Soil.

Encroachment of the sea.

The action of the waves, and of the winter frosts, in undermining and abrading the sea cliffs, causes a constant encroachment of the sea upon the land, the rate of which varies at different points. At one place, where exact observations, extending over a period of thirty years, were made by Mr. Richard Brown, he estimated it at five inches annually. A remarkable effect of this disintegrating process is visible on the coast between Low Point and the Barasois, and is thus described by Mr. Brown: "A mass of strata, half a mile in length, two hundred yards in width, and twenty yards in height, resting upon a seam of coal, having a strike parallel with the coast line, and dip sufficient to bring the force of gravity into action, has slipped down bodily, owing to the softening of the underclay on one side by land-springs, and on the other by the action of the surf. The *débris* of the fallen mass, at the foot of the cliff, before this time, has probably been ground into mud and sand by the waves; but the course of the landslip may be distinctly traced from end to end, by means of the long rugged gaps and holes left on the surface." I may add that in the width specified, not fewer than twelve of these furrows were observed, extending nearly the whole length of the landslide.

Effect of the ignition of the Hub coal seam.

At Burnt Head, in the vicinity of Glace Bay, the Hub coal seam has been ignited, either intentionally or by accident, and the long continued and intense heat produced by its slow combustion, has baked and hardened the associated shales, and altered their texture and color to such an extent, that the fragments strewn along the beach, when rounded and polished by the action of the waves, can scarcely be distinguished from pebbles which might occur in any region of ancient metamorphic rocks. A precisely similar case is described by Sir Charles Lyell,* as occurring at Russell's Hall, near Dudley, Staffordshire, where coal seams have been slowly burning for ages, and he shows that the effect upon the neighboring strata corresponds exactly with that caused elsewhere by intrusive granite.

I have the honor to be,
Sir,
Your obedient servant,
CHARLES ROBB.

GEOLOGICAL SURVEY OF CANADA,
MONTREAL, *May*, 1875.

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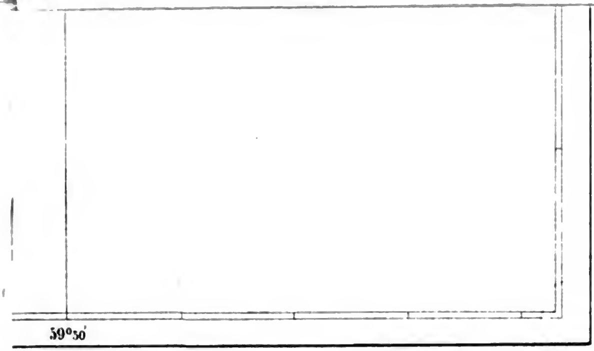
* Elements of Geology, 2nd Edition.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* Elements of Geology, 2nd Edition.

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OBSERVATIONS

ON

THE HISTORY AND STATISTICS OF THE TRADE AND MANUFACTURE OF CANADIAN SALT.

BY

J. LIONEL SMITH,

ADDRESSED TO

A. R. C. SELWYN, Esq., F.R.S., F.G.S.,

DIRECTOR OF THE GEOLOGICAL SURVEY OF CANADA.

SIR.—I have the honor to report on the results of my visit to the salt works of Ontario, undertaken in accordance with your instructions given me in May last.

Difficulty of obtaining information.

Although courteously received by the proprietors and officers of the various works, I found an evident reluctance manifested by some to impart details of their business. In many instances I was told that full returns had already been forwarded to you, which obliged me to leave blanks in my note-book, to be filled up at Montreal. But on inspection of the alleged "full returns," I found that they were very defective, many important questions being either imperfectly answered, or not answered at all Some of the required information has been supplied by correspondence; but it was found necessary, in order to complete tabulated comparisons, to fill up gaps with approximate results obtained from other manufacturers. While, therefore, the information obtained is not quite so complete as is desirable, it is, nevertheless, important and considerable, and will, it is hoped, afford a fair insight into the present extent and position of the salt producing industry of Canada.

Tables.

For easy reference, as much as possible of the information obtained is classified in the annexed tables.

On reaching the salt region, I found that the manufacturers were much gratified by the prices their salt consignments were obtaining in Chicago and other Western markets. The Grand Trunk Railway authorities had enabled the Seaforth, and other inland manufacturers, to send their salt to the Chicago market at the reduced freight charge of 90 cents per barrel; so that the balance of previous seasons' stocks was profitably disposed of.

Cost of carriage to Chicago.

Most of the salt made at Goderich and Kincardine is shipped to such western markets of the United States as are within reach of water-carriage, and as far west as Duluth, salt forming a return cargo for western products. The situation of wells at, or near, these two lake ports, gives to the manufacturers an advantage of 16 to 20 cents per barrel over those farther inland; since, in conformity with the general custom of railways to charge an increased rate for freight moving *back* or over short distances to water lines, the Grand Trunk Railway Company charges 17 cents per barrel of salt from Seaforth to Goderich, and 16 cents from Clinton, which is only twelve miles from Goderich. On arrival at Goderich 3 cents per barrel has to be paid for cartage. Nearly all the Goderich wells are also subject to the charge for cartage to the port or railway, but the Kincardine wells, being close to the harbour, no cartage is there necessary. One of the latter (the Bruce well) has unusual facilities for shipping, inasmuch as the works occupy a terrace, with the Penetangore River, or Creek, on two sides, and a lake wharf on the third.

Advantageous situation of wells.

G. T. R. charges.

Cartage.

Facilities for shipping at the Bruce well.

As the inland manufacturers have necessarily to cultivate the inland or Canadian markets, their salt is brought more into competition with that from Liverpool; and, as will presently be shown, this competition bears so heavily upon them, that it must check the progress of works inland, and promote their increase along the lake shore.

PRESENT STATE OF THE CANADIAN SALT TRADE.

Since Dr. T. Sterry Hunt's visit to the Goderich salt region in 1869, only eight wells have been sunk that are productive, or at present in operation. The difficulties (arising from restricted markets) which beset salt-making in Canada, have not only prevented the boring of many more wells, but have checked production and improvements at wells already equipped and in action.

Difficulties befetting salt making.

To estimate the condition and future prospects of the salt manufacture in Western Canada, we must look at all the circumstances by which it is influenced. The total export trade of Canada requires so much more tonnage than the import trade can profitably supply, that ship owners, or their representatives, are often glad to load their vessels with salt for Quebec or Montreal, at mere nominal rates of freight, in preference to carrying dead, or waste ballast, which, besides the cost of loading and unloading, involves heavy expense for lighterage.

Cheap carriage of English salt.

Fine salt from Liverpool is frequently laid down at Quebec at five shillings sterling per ton of 2,240 lbs, while solar, and sometimes coarse salt, are brought out simply as ballast without any freight charge. The Chicago salt manufacturers likewise frequently dispose of surplus stocks in Canadian and other foreign markets, at prices lower than they are willing to accept in the home market. English salt, consequently, can often be bought at a less price in Montreal than in Liverpool. Thus we have an exception to the general law, according to which the value of a product depends upon the distance from the point of production. In its progress inland, English salt has the further advantage of travelling at a less rate of freight westward, than Canadian salt can eastward, and may thus supply western markets at prices below those obtained for the native product in the eastern markets.

English salt bought for less in Montreal than in Liverpool.

At first our manufacturers were content to compete with Liverpool salt in markets west of Toronto. Demand for their salt, however, gradually extended further east. Its price necessarily increased as it progressed in this direction, while that of Liverpool salt proportionally decreased; until at Montreal, and in our eastern districts, Ontario salt can only be sold when the stock of Liverpool salt is much reduced. In 1873, the high prices of labour and fuel in England so raised the price of salt there, that it could not be exported at the low prices of former years. The consequent improvement of United States and Canadian markets materially assisted our manufacturers.

The importations of Liverpool salt into the Dominion apparently attained a maximum in 1870; since then there has evidently been an annual displacement of English by Canadian salt, as is shown by the following extract from the returns of the British Government. Canadian returns I found to be defective.

Importations of English salt.

Salt Exports to the Dominion of Canada.[*]

1870..............	81,169	tons.	=	3,246,760 bushels.
1871..............	76,005	"	=	3,040,200 "
1872..............	54,076	"	=	2,163,040 "
1873..............	24,800	"	=	992,000 "

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[*] It may here be remarked, that 56 lbs. of salt = 1 bushel; 5 bushels = 1 barrel; 40 bushels or 8 barrels = 1 English ton; and 35.71 bushels or 7.14 barrels = 1 Canadian ton.

The importations of salt, for 1874, are supposed to be at least double those of 1873, which, as already explained, was an exceptional period.

United States duties.

Thus, on their eastern side, we see our manufacturers in constant conflict with a torrent of cheap English salt, flowing around them, and to the western markets beyond. On their western side there have been still other obstacles. To gain admission to markets beyond the frontier, a duty of 68 cents per barrel had to be paid, and $3.60 per ton of loose salt; although United States salt was admitted duty free to compete with theirs around their own wells.

The superior quality of Ontario salt was soon recognised, and after driving United States salt quite out of Canadian markets, our manufacturers began to ship salt in consignments to Chicago. But the duty, consular fees, commission, storage, and other charges incident to consignments, only left to them a small profit at best of times, and frequently entailed such losses that many of the salt companies became embarrassed, and were obliged to sell their property at a great sacrifice, or to close their works.

In 1872, the United States Government reduced the customs' duty on salt 50 per cent. This gave Canadian salt a better chance in American markets, and since then our salt-works have been in a more active and prosperous condition; but the manufacturers have still to face a United States duty of 8 cents per 100 lbs. on bulk shipments, and 12 cents per 100 lbs. on barrel salt, or nearly 34 cents per barrel, besides a consular fee of $3.00 on every invoice or bill of lading.

Increased size of factories.

The wells sunk since 1869 have been for the service of larger blocks or factories than were previously constructed. The "International Works" at Goderich, lately completed, are on a very large scale. They are built in four blocks, each provided with pans of twelve by twenty-four feet; the pumping capacity is 44,000 gallons of brine per hour, and the production of salt as high as 800 barrels per day.

Use of kettles being superseded.

Since 1869, evaporation with kettles has (with one exception, viz, at the "Huron Salt Works," which, however, have been closed since 1871) been superseded by the use of large quadrangular iron pans, the dimensions of which vary according to different systems of heating (see Table III.) The substitution of pans for kettles was an important improvement, as it at once increased the capacity and reduced the cost of manufacture.

A system of evaporating in wooden vats, heated by steam piping, is now being indroduced, and has both economy of construction and maintanance to recommend it. By this system the "Ohio River Valley Salt Company" makes good salt from brines fifty per cent weaker than those of Ontario; but it appears to be better adapted for strong brines.

DENSITY OF ONTARIO BRINES; GYPSUM; EARTHY CHLORIDES.

Strength of Ontario brines.

The salometer shows that the brine has not decreased in density in any of the Ontario wells since they were opened, nor, in so far as can be judged from a comparison of the amount of salt produced with given quantities of fuel and brine, has the proportion of chloride of sodium diminished. To what extent the latter salt contributes to the density of the brine can only be determined by analysis. Where the saliferous beds are from eighty to one hundred feet thick, and contain beds of rock salt, the brine is not likely to diminish much in strength. That which is drawn, however, from between the first and second strata of rock salt is not generally so strong as that which comes from between the second and third. The former ranges from 75° to 90°, and the latter from 85° to 100° of the salometer. The minimum points in both cases are arrived at when the wells have been pumped very freely, the brines returning to their maximum density when pumping is again relaxed.

Sulphate of lime.

Wherever there is rock salt, well-borers are prepared, by experience, to meet with sulphate of lime or gypsum. The Ontario salt-beds are all more or less impregnated with it; but I found by the records of different wells that the proportion not only varied in different localities, but occasionally also in different borings in the same locality. The brines from nearly all the wells at first contained a sensible amount, and in some cases the quantity was considerable. This difficulty was met by the use of gypsum pans, which were set at the back or bank end of the blocks, where the heat is lowest. The brine was first run into these pans, where, at a temperature of from 110° to 120° Fahr., the sulphate of lime was deposited, and the brine flowed thence through syphons into the crystallizing pans, where it was further heated to 160° for coarse salt, and to from 200° to 212° for fine salt. When the quantity of sulphate of lime is insignificant, as at Kincardine, and in most of the Goderich wells, special pans for its removal are not generally used, and in some instances where they were formerly employed they are now discarded, the reason assigned being, that the brine has gradually become free from sulphate of lime. The testimony on this point, however, was not uniform, owing, probably, to the fact that the brines are derived from different strata.

Chlorides of calcium and magnesium.

In the deliquescent chlorides of calcium and magnesium (the so-called earthy chlorides) salt-makers have a more subtle antagonist to contend with than sulphate of lime. When present in salt they keep it in a moist condition, or, in dry situations, cause it to cohere in massses or lumps; either condition at once indicating to the butter-maker and the meat-curer its unfitness for their respective puposes. On the other hand, it is said that salt containing these chlorides is the best for cheese-making, probably on account of the tendency which it would have to prevent the cheese becoming too dry.

By the analyses of Dr. Hunt, and Dr. Goessmann (1867 and 1868), it was shown that Ontario brines were comparatively free from the chlorides of calcium and magnesium. From my mercantile experience with Ontario salt, however, and from observations made under your instructions, it would seem either that their proportions in the brine have since increased, or that their presence in the salt must be accounted for by carelessness in not running off the mother-liquor often enough from the pans. Dr. Hunt has shown that in one instance, at Goderich, these chlorides had accumulated four-fold in the pan from this very cause.

Opinions of manufacturers concerning earthy chlorides.

Amongst the manufacturers I met with four different opinions on this subject. There were those who scouted at the idea of any earthy chlorides being in their brine; those who thought that there "might be traces," but not sufficient to be worth paying any attention to; those who admitted their presence, but did not see the necessity of incurring trouble or expense to get rid of them; and lastly, those who not only admitted their presence, but were anxious to find out the best means of removing them.

Means of getting rid of earthy chlorides.

Carbonate of soda is largely used by English and other manufacturers, as a means of decomposing the earthy chlorides. By it the lime and magnesia are precipitated as carbonates, while the chlorine and sodium combine to form chloride of sodium or salt. In order to decompose the chloride of magnesium, Muspratt recommends the use of milk of lime, which precipitates the magnesium as hydrate.

Dr. Hunt states, in his report, that at Syracuse dairy salt is prepared by "washing the previously drained salt in a pure saturated brine, to which has been previously added a sufficient proportion of carbonate of soda to decompose the earthy chlorides present in the salt; the proportion being determined by the results of analysis. The salt is then drained and partially dried in bins, after which the drying is completed in hot air chambers. This method may answer for salt intended for a specific purpose, but causes a waste of too much time and labour for the ordinary salt of commerce, The objectionable chlorides must be disposed of in the brine, and before the salt is made, to secure economic results.

Dr. Gouinlock, of Seaforth, states as his conviction that the soluble chlorides increase in the brine as the area enlarges from which it flows.

SOLAR SALT.

Uses of solar salt.

This salt is used in pork and beef packing, and in the curing of fish, and is indispensable to their preservation on long sea-voyages, and in hot climates. It is valued chiefly on account of the large size of its crystals, the result of slow solar evaporation. Large crystals are sometimes also produced by slow evaporation with artificial heat, but it is stated that meat and fish curers regard them as inferior to the salt produced by solar evaporation.

Solar salt imported by the United States.

More or less solar salt is made in every salt manufacturing district in the United States, which country, nevertheless, imports from six to seven millions of bushels annually. Although the Canadian brines are well suited for the purpose, it has not hitherto been made in Canada, and its production would alone be profitable if the cost were such as to enable our manufacturers to compete with those of other countries. The great and increasing demand for solar salt should stimulate its manufacture.

There is no apparent necessity for adopting the expensive system of salt rooms and covers used at Syracuse and other places. The imported article is the product of natural salines in the West Indies and South America; or of solar evaporation in artificial earth pits in Portugal, and on the Mediterranean coasts of Spain and France.

Arrangement of sal'nes at Setubal.

The arrangements of each saline at Setubal, in Portugal, may be briefly described as a vast reservoir from two and a half to five acres in extent, divided into oblong spaces by embanked paths three and a quarter feet wide, with a basin or feeding reservoir at one end. The oblong tanks are about eight inches deep. They have a main inlet from the basin, and a main outlet for carrying off exhausted, or superfluous sea-water. In autumn the sea-gates are opened, and the whole area inundated, to a depth of twelve inches. The water is left to evaporate until the end of May, when the tanks are cleaned out, and recharged, from time to time, from the basin. Under the influence of the north-east winds evaporation is so rapid, that in twenty days each tank bottom is covered with a layer of salt about two inches thick and almost dry. This is the first crop. The second crop is ready in another twenty or thirty days; but brine for the third crop is let into the tanks before the second crop is raked out. If the weather proves unfavourable to the third crop, the whole area is again inundated for the winter. The time and labour spent in making solar salt from sea water, which yields only two and a half per cent., is immense compared with what is required to make it from brine yielding 25 per cent.

Strength and purity of Goderich brines.

Both Dr. T. Sterry Hunt and Dr. Goessman have testified that the brine of the Goderich region is one of the strongest and purest known, and that it is especially adapted to the making of solar salt, owing to its comparative freedom from the earthy chlorides. There seems, therefore, no reason why our salt manufacturers should not make it in pits, or ground vats, lined with a proper cement, excellent materials for which they have at hand.

Conditions of the atmosphere.

The general condition of the atmosphere as regards moisture in salt-making localities during the season of evaporation is more important than the number of days on which rain falls; and the number of unclouded days during this period is likewise important. In Ontario the summer months will compare favourably in these respects with any country in Europe, and the trouble and expense of covers might probably be dispensed with, as it is doubtful whether the shade they give does not retard evaporation to an extent hardly compensated for by the protection they afford against rain.*

Proper site for works.

Great care should be taken in selecting a site for solar salt works, as evaporation is proportional to the amount of moisture in the surrounding atmosphere. The ground should be of such a character as to admit of easy drainage, and every precaution employed in the arrangement of the ground vats or pits.

Facts from the United States census returns.

If by experiment ground vats were not found suitable to our climate, a less costly system of raised salt rooms than is used at Syracuse would, no doubt, be found sufficient, as explained by Dr. T. Sterry Hunt in his report of 1869. Although solar salt is so valuable to our fish-curers, it is remarkable that no attempts have been made to manufacture it in our maritime provinces; whereas, in the eastern states of the Union, salteries have been used for its manufacture from Cape Cod to Georgia, and from the earliest period of their history. The following facts on this subject are taken from the census returns of the U.S. Government: —The first saltworks in New England were erected in 1623, near Portsmouth, in New Hampshire. Saltworks were erected in New Netherlands

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* The following returns of rain-fall from the Toronto Observatory may be interesting in this connection; they are the only ones which I have been able to obtain:—

Goderich	May to September,	1871,	30 days,	5.95 inches.
Kincardline	" "	1871,	28 "	4.74 "
Ontario................	" "	1872,	29 "	7.48 "

by the Dutch previous to 1649; but in that year a Mr. De Wolff received a grant of Coney Island for the manufacture of solar salt. In the exercise of this right he was resisted by the Connecticut settlers at Gravesend, on Long Island, "where, in early times, salt was made by exposing sea-water in shallow vats along the shores."

In 1652 salt works were set up at Cape Ann. In 1746 evaporating pans were erected along the coast of Connecticut. In 1775 large salt-works were established at Cape Cod. In 1777 John Sears and others started saltworks at Dennis, in Barnstaple county, where they built a vat 150 by ten feet, and covered it with "a curious roof." In 1800 Hattel Tilley, of Massachusetts, took out a patent for a method of covering vats by a revolving roof, and is said to have made the manufacture of salt "more economical by extracting from the mother waters crystallised sulphates of soda and magnesia."

During the War of Independence, and for some time afterwards, salt-making from sea-water was conducted with increased vigour and skill, and works multiplied so rapidly along the coasts of all the States, that it would be tedious to enumerate them.

United States duty repealed in 1807.

In 1789, a duty of six cents per bushel was imposed on all foreign salt, and this in the following session was raised to twelve cents, and in 1797 to twenty cents per bushel; but in 1807 the duty was entirely repealed. In July, 1813, the duty of twenty cents was again imposed, and continued until 1832, when it was reduced to ten cents per bushel, and again in 1842, to eight cents per bushel.

The salt works in the State of Massachusetts were exempt from taxation; and in 1820, the State had a capital of $777,000 employed in salt making. In 1827, when petitioning Congress against the reduction of the duty it was stated that "the salt works of the State are numerous, and make annually, chiefly by solar evaporation, 600,000 bushels of the best salt, and the salt works of Barnstaple county alone, are valued at $1,300,000, and owned by 1,000 people." At this time large quantities of solar salt were also made in the State of Maine.

After the reduction of the duty to eight cents, a rapid annual decline of the sea-salt manufacture followed, which was accelerated by the growing manufacture at the Onondaga Salt Springs.

Unfavourable circumstances along portions of our coast

The higher latitudes and lower temperature of portions of the maritime coasts of Eastern British America are, no doubt, opposed to similar attempts at salt making; while the fogs which prevail during the summer months are natural hinderances to solar evaporation.

FREEZING METHODS.

ntroduction of freezing nethods.

Methods are employed in Russia for the manufacture of salt from sea-water which might, perhaps, be profitably introduced along our sea-coasts, and on the shores of the Gulf, as far up as the Island of Anticosti. They depend upon the fact that when sea-water or brine is cooled to a few degrees below the freezing point, a portion of the water is converted into ice, and a more concentrated brine left behind.

In some cases the sea-water is let into a large basin, where, during the winter, it becomes frozen to a considerable depth. In April, or as soon as the spring is imminent, the concentrated brine is drawn off from below the ice into deeper reservoirs or pits, which present less surface to the rains, and are protected by embanked sides from surface drainage; and from these it is pumped into the evaporating vats. The more general plan, however, is to confine the sea-water in long and narrow areas, and to remove the ice from the surface, almost as it forms. Whether the evaporation is completed by solar or artificial heat, I have not been able to ascertain.

EVAPORATION IN WOODEN VATS.

The "Ohio River Valley Salt Company" make salt from weak brines of only 35° to 40° of strength, in wooden vats heated by steam piping. The vats are from 100 to 150 feet long, ten feet wide, and twelve inches deep, and the evaporation is effected by steam, conducted through five iron pipes of five inches diameter, and raising the brine to a temperature of from 160° to 200° F.

Utilization of waste steam.

The owner of a steam flouring-mill at Seaforth, Mr. W. Marshall, conceived the idea of utilizing the waste steam from his engine in the manufacture of salt, and erected last summer a small salt block alongside of his mill; this block he supplies with brine from the "Merchants well," the evaporation being effected by steam conducted through galvanized iron pipes around the bottom of a wooden vat, eighty feet by fourteen and twelve inches deep. By this means the brine is heated to a temperature of about 200° Fahr. Mr. Marshall makes about thirty barrels of salt per day, and so profitable has the adventure proved, that he intends to enlarge the works. The profit thus made from steam that would otherwise have been wasted, pays, I was told, the cost of the fuel for the driving power of his mill.

As the salt region is in the midst of one of our largest and best wheat-growing districts, the knowledge of this fact is likely to multiply flouring and other mills for which steam power is required.

Advantages of wooden vats.

A great advantage of this method of evaporation is the diminished cost of construction, and the greater durability of wooden vats, as compared with iron pans, which cost from $5,000 to $6,000 each, and have to be renewed about every five years. It remains to be proved, however, whether sufficient heat can be obtained to make the finest grades of salt.

Salt blocks in connection with flouring-mills.

Already, with their usual sagacity and enterprise, the Messrs. Ogilvie, of Montreal, have bought the large steam flouring-mill at Seaforth, with the intention of erecting alongside a salt block, 100 feet long, and ninety feet broad, fitted up with a wooden vat, ninety by twenty-two feet and twelve inches deep. Around the bottom of the vat will run a six inch iron main-pipe, for the conduction of steam, which will feed 112 half-inch brass pipes, the ends of which will be set in the main-pipe at each side. They expect to commence evaporating in April or May next, and to make seventy-five barrels of fine salt per day.

Messrs. Ogilvie are also erecting a very large steam flouring-mill at Goderich, with a large salt block alongside. It is close to the harbour, and near the Hawley well, which will supply the brine. The block is to be 130 by ninety feet, with two wooden vats of 120 by twenty-two feet each. These will be furnished with six-inch brass main-pipes around the bottom, united in the same manner as in their vat at Seaforth, by half-inch brass pipes, 152 to each vat. Evaporation is to be begun in May or June, and it is expected that 150 barrels of fine salt will be produced per day.

EVAPORATION OF WEAK BRINES.

Wells abandoned.

As indicated elsewhere, many wells have been bored in Canada, which have cost large sums of money, and have afterwards been abandoned as useless, because rock-salt was not met with, even in cases where brines were abundant with a density of 35° to 60° of the salometer. The proprietors naturally concluded that the treatment of such brines would be unprofitable, owing to the large amount of fuel which would be required for their evaporation. The utilizing of weak brines is, therefore, largely a question of the cost of fuel—a subject which will be discussed under its appropriate heading.

Cost of fuel.

It is desirable, however, to notice here the way in which weak and impure brines are sometimes profitably used in other countries. Much of the salt used in France and Germany is made from saline waters,

aggot
radation.

which scarcely deserve the name of brine. Various contrivances were formerly in use in these countries for increasing evaporation, by enlarging the surfaces; but a method, known as *faggot gradation*, was introduced into Lombardy, and thence into Germany and France, which superseded all others. According to this method, the brine is pumped up into an elevated cistern, and then allowed to trickle through bundles of thorn branches, built up in the form of a wall, and standing in the middle of a large reservoir. This wall of branches is often 1,500 feet long, nine feet thick at the base, and six feet at the summit. The cistern, which is securely braced by wooden beams, is supplied on both sides with numerous taps, which, during evaporation, are left open on the windward side. From careful experiments, it appears that, under ordinary circumstances, thirteen gallons of water are evaporated from every square foot of thorn wall in twenty-four hours. When the brine in the reservoir, around the base of the thorn stack, attains a density of about 1·15, it is run into large settling reservoirs, and just enough lime added to decompose the chloride of magnesium. It is then pumped into evaporating pans placed over furnaces. These pans are kept full until the saturation point is nearly reached, when the brine is run off into other pans for crystallization.

hio River
alley.

In the salt districts of the Ohio River Valley, weak brines are profitably employed, although pumping wells have to pay "dead rents" to those not pumping, and have absorbed in sinking as much or more capital than the Ontario wells. Some of the wells in this region are from 1,500 to 1,800 feet deep; but the average depth is about 1,000 feet.

In the "Report of the Select Committee on Transportation Routes," lately printed by order of the U. S. Government, I find the following testimony of Dr. J. P. Hale:

estim ny of
r. Hale.

"We measure the strength of the brine by an hydrometer graded from 1° which marks fresh water, to 25° which marks point of saturation. By this, the strength of brine at different wells is indicated to be from 8° to 12°, or an average at working wells of 10° " *

"We granulate our salt in large wooden vats, heated by steam pipes running through them. Our vats are about ten feet wide, 100 to 150 feet in length, and eighteen inches deep. There are generally five principal pipes, about five inches in diameter, passing through, which are supplied with steam at a temperature of 160° to 200°."

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* This would be equal to 40° by our salometer.

As this system of evaporation can be, and is profitably united with other steam industries in Ontario, our weaker brines should be thus turned to profitable account.

ROCK SALT.

This is likely soon to become another product of our salt region. From its apparent purity, and from the thickness of the bed, it has been concluded that it could be profitably mined, and I was informed that Mr. H. Attrel, a gentleman of wealth and enterprise, had secured land, and intended to sink a shaft for the purpose, if the Government would meet his views with regard to harbour accommodation. Such an enterprise would have not only a commercial, but a special geological interest, and it is to be hoped that the Government will yield all possible assistance. Unfortunately Mr. Attrel was from home at the time of my visit, and I was, therefore, unable to obtain more precise information concerning his intentions.

Mining of rock salt.

TABLE SALT.

In the annexed tables, the names of three of the principal makers of "table and extra dairy salt" are included. Two of them buy salt from the owners of various wells, and after super-drying and crushing, offer it for sale in a very fine white and dry state. It is put up in packages suitable for retail dealers, and also in kegs and barrels, as required by butter and cheese makers. In the making up of the smaller packages, considerable juvenile labour is employed.

The first factory of this kind was started by Mr. J. Belfry, of Clinton, who super-dries the salt by passing it through a large cylinder which revolves over a fire, and slopes just enough to let the salt run through in a constant stream. It is then crushed by being passed between iron rollers.

Mr. Belfry's factory.

In 1872, Mr. Samuel Platt, of Goderich, gave an impetus to the demand for this kind of salt, by improvements in its preparation. Instead of crushing the salt between rollers, Mr. Platt, after super-drying, grinds it between a horizontal pair of stones, and dresses it by revolving *reels*, like those used in flouring-mills. From the superior appearance of his salt, and from the convenient packages in which it was put up, a large demand was at once secured for it.

Improvements in manufacture.

Messrs. Coleman & Gouinlock have started a factory of this sort, in connection with their extensive salt works at Seaforth, and are now manufacturing very fine salt for table and dairy purposes.

Coleman & Gouinlock's factory.

All the Ontario makers of table salt super-dry it by heated revolving cylinders.

METHODS OF PACKING SALT.

Ontario salt is shipped to market in barrels, in bulk, or in bags; its shipment in bags, however, being very limited. When Liverpool coarse salt becomes scarce at Montreal or other points, a few thousand bags of Ontario salt are packed for such markets, in old Liverpool salt bags, or in others of inferior size or quality. The only bags now made in Canada are of flax or cotton, and are too costly for salt.

Bags.

Bags for salt should be strong, of close texture, and not sewed with tarred twine, as is the case with those imported for grain. On account of price, they are necessarily made of jute, and imported from Britain. Including a duty of seventeen and a half per cent., an ordinary four-bushel bag costs, laid down at the salt works, about twenty-two cents; and a superior bag of bleached jute and flax for "factory filled" salt, costs nearly forty cents.

Comparative advantages of barrels and bags.

Barrels which hold five bushels are worth from twenty-eight to thirty cents, so that, in so far as cost for packing is concerned, there is little apparent advantage in substituting bags for barrels. In other respects, however, there are marked advantages. A barrel weighs about twenty-five pounds, and with 280 pounds of salt, 305 pounds. The regulation weight for railway cars to carry, is 21,000 pounds; and railway companies will only allow seventy barrels of salt per car. (= 19,600 lbs. of salt, and 1,750 lbs. the weight of the barrels), while they carry at the same freight charge, 100 bags of Liverpool salt, containing four bushels each (400 × 56 = 22,400 lbs.), or 2,800 pounds more salt, making a difference in the cost of carriage of twelve and a half per cent. in favour of the bags.

Undoubtedly, our manufacturers could compete better with those in England if they took equal pains in curing the salt, and turned it out in bags of equal size and character.

Oblong blocks of salt.

The oblong blocks of salt common in England, and which require no packing, would, I think, be convenient and profitable, if made here. They are prepared as follows:—The salt is scooped out in its wet state, from the pan into wooden moulds, about thirty-six inches long, eighteen inches deep, nine inches wide at the top, and seven inches at the bottom, in which are slits for the escape of the moisture. When filled, the salt is pressed down, and then removed to a perforated floor. After twelve hours' drainage there, the moulds are carried to the drying chamber, where the blocks of salt are tilted out, and ranged separately on shelves.

When sufficiently dried, the blocks or parallelopipedons of salt are removed to the storehouse. Each block weighs thirty pounds, when dried. The cheapest kind of labour (frequently women) is employed in filling the moulds and in moving them.

Salt bears carriage well in this form, which, however, is especially adapted to inland transportation. It is convenient for consumers, who scrape, or slice off, what they immediately want. And retailers divide the blocks easily with long knives.

INSPECTION OF SALT.

The very damp condition in which Ontario salt is too often sent to market must be attributed rather to its not having been properly drained, or cured, than to the presence of earthy chlorides in it.

The principal manufacturers of Goderich, Kincardine, Stapleton, and Seaforth, are now paying more attention to the condition of their salt at the time of shipment; and this has not only improved the sale and character of their respective brands, but also added to the reputation of Ontario salt generally.

Compulsory inspection.

Shipments of improperly cured or *green* salt to American markets have been so detrimental to the reputation of Canadian salt there, that the principal manufacturers are in favor of a compulsory inspection, whereby the salt would be classified according to quality and condition. They are willing to pay two cents per barrel, and ten cents per ton on bulk shipments, as a necessary tax for cost of inspection. A bill having this object in view was brought before the Ontario Legislature during the last session; but clauses were introduced into it which were so objectionable to the salt manufacturers generally, that they strongly opposed it, and it was eventually withdrawn.

There is no doubt that a salt inspection would not only prove serviceable to the manufacturers, but also to the Government, in facilitating the collection of correct annual returns.

FUEL.

Cost of wood.

The question of fuel is one of the greatest importance to our salt manufacturers. Hitherto they have relied almost exclusively upon wood, which has been regarded as the cheapest fuel. By reference to Table VII. it will be seen that its present average cost is little under $3 per cord, and that nearly $1 0,000 are annually expended for wood alone. The price has doubled since 1867, and must necessarily go on increasing, although not in the same ratio, since coal from Cleveland already competes with wood at our Lake ports.

Comparative value of coal and wood.

By enquiries among manufacturers, I find that one ton of anthracite coal is considered equal to one and three-quarter cords of hard, and to two and a quarter cords of soft wood, for the production of steam, and one ton of bituminous, or Cleveland coal is equal to one and a half cords of hard, or two cords of soft wood.

Coal can now be delivered at Goderich from Cleveland at from $4 to $4.25 per ton; and Mr. John Ogilvie tells me that they intend to use this coal in preference to wood at their large steam mills, now in course of erection at Goderich; also that many of the salt manufacturers are using it now. Last season, during my visit, the price of coal was much higher than at present, and wood was then the only fuel.

Dr Sterry Hunt gives the quantity of salt made from one cord of hard wood, as thirty-five bushels, or seven barrels only. But since his visit the system of evaporation has been so entirely altered that the proportions are now very different. By reference to Table III. it will be seen that there is a great variety in the methods of heating the brine; and there is a similar variety in the results. My notes show that different manufacturers claim ten, twelve, thirteen, and fifteen barrels of salt, as being made by them respectively per cord of hard wood; and the Merchants Company at Seaforth claims as high as seventeen and a half barrels, or eighty-seven and a half bushels of salt per cord. Any one of the different methods of evaporation now in use is better than the old plan with kettles, the unfitness of which for Ontario brines was pointed out by Dr. Hunt, who argued that, as Goderich brine was fifty per cent. richer than that of Syracuse, a proper system of evaporation should yield fifty per cent. more salt for like quantities of fuel; a result which has been exceeded.

Dr. Hunt thought wood, as compared with coal, to be the cheaper fuel. But, at the relative prices of these two fuels, the advantage now is five per cent. in favor of coal. And, admitting that one ton of coal is equal to one and a half cords of wood, and the average production per cord, to be now, say, sixty-eight bushels, one pound of coal will make nearly two and a half pounds of salt, instead of one pound, as formerly insisted upon.

The manufacturers at Goderich and Kincardine talked complacently about the large forests to the north of them, and of the facilities for obtaining from them abundant supplies of fuel. Any serious augmentation in the price of cordwood, therefore, was considered as too distant to affect them. But such calculations are especially unsafe in a country where large forests are so rapidly disappearing, and where extension of railways may soon increase the consumption of wood many fold. Wood cannot be the fuel of "the future" for our salt industries, nor is it, at "the present," the best or cheapest fuel for them. Manufacturers use it more from habit, than from necessity; as coal, even now, is cheaper than cordwood, and liquid fuel, which is in abundance alongside of them, is, as will be presently shown, cheaper than coal. And cheaper fuel means not merely reduction in the cost of their product, and consequently larger profits, but also an enlargement of their powers to compete successfully with the foreign product, and increased attractions for correlative industries, and for population to settle around them.

Petroleum.

Liquid Fuel.—Overlying the Onandaga formation, from which the brines of Ontario are derived, is the Corniferous formation—the source of the petroleum. This substance, as is well known, is capable of producing a high degree of heat when burned in connection with steam, and affords a fuel which will probably be found to be cheaper than either wood or coal. Mr. M. P. Heyes, of Seaforth, patentee of an improved system of heating furnaces, states, however, that petroleum has been tried, and was not found to be more profitable than cordwood. But so little have liquid fuels been experimented upon in this country, and so little is known here of the necessary conditions to obtain the most profitable results, that such trials as have already been made, cannot yet be accepted as conclusive.

Waste from oil refineries.

Our salt manufacturers, however, can have, in the waste of our oil refineries, a still better and cheaper fuel than petroleum. This waste, I am informed, frequently accumulates to such an extent as to oblige refiners to stop their works.

Information published by Capt. J. H. Selwyn.

For information respecting the value of this fuel I am indebted to a series of papers by Capt. Jasper H. Selwyn, R. N., published in 1870. By a course of experiments, conducted for the Royal Navy, and by the evidence of several manufacturers, Captain Selwyn proves, that this crude form of creosote, is the cheapest and most powerful steam-raising fuel known.

The following extracts may serve to ensure the attention, and direct the efforts of our manufacturers:

"The particular hydro-carbon to which I wish to direct your attention, is known as 'creosote,' 'dead earth oil,' and 'acid foots.' The first name I prefer, as being most generally known. Creosote is the refuse product of the distillation of tar. About 60,000,000 gallons are made, and in part wasted in Britain alone. But this is of little importance, as it is certain that any required amount of it can be produced without greatly enhancing the price. First, wherever coke is made; secondly, wherever shale exists; thirdly, wherever coal distillation for obtaining illuminating oils is carried on; and lastly, from petroleum itself, of which this is in one form a refuse."

"The supply, indeed, is much more widely distributed, and much less likely to be exhausted than that of coal."

In speaking of the method of using it when liquid, Capt. Selwyn says: "In the roughest application, all that is necessary is to bore a hole above the fire-door, to take two iron pipes, say half inch, and bend them so that they look into the furnace, one over the other. Then to the lower one connect the steam, to the upper the oil, and your fire bars having been covered with a thin bed of glowing ashes, the boiler is ready to work, night and day, or as long as the oil lasts. When solid, it is melted in tanks by waste steam-pipes, and then conducted to the furnace."

A better way of using the fluid is briefly referred to, and that is, by an injector, attached to the two pipes, and set in the mouth of the furnace.

Speaking of one of the manufactories where this fuel was used, Capt. Selwyn says: "The water has been here carefully measured, for a fortnight, and amounts to 23 pounds of water for every pound of fuel. The combustion was attended with no smoke, and but little light or flame. A blue glow of burning carbonic oxide pervades the furnace. The bed of ashes remains glowing, but is more blown than burnt away. The ash-pit not being closed up, an undue, certainly an unknown, quantity of air enters. This should be very carefully avoided, as every excess is injurious to the effective heating power of the boiler.

"According to Messrs. Favre and Silliman, and Professor Rankin, 27 pounds of water is the result of its perfect combustion. The best results, with coal at sea, fail to give us more than seven pounds of water evaporated by one pound of coal, whereas three times this is being daily exceeded."

Of another factory, it is said: "Here the furnace end of the boiler was entirely changed, *i. e.*, the fire bars had been taken out, and the end built up with fire-brick. The fire-door was inserted in this, about its usual place; and above it was a conical hole, by which the jet or injector entered. Less air was thus admitted, and only in close combination with the jet. Inside, all the fire-bars had been taken out, and where the jet played there was a sort of cupped arrangement of the fire-brick. On enquiring of the Manager about the fuel used, I was told, first, that about 3 tons of Butterly coal had been formerly used daily, (*i. e.*, in the twenty-four hours) to fire the boiler; and then, taking me into the office, he showed me the account for the week to be, an average of 109·8 gallons daily. That is, that 1,090 pounds of creosote were steadily doing the work previously done by 6,720 pounds of coal.

Work done by "creosote" and coal.

BORINGS.

Since Dr. Sterry Hunt's visit in 1869, there have been comparatively few bore-holes put down, and even within the recognised limits of the salt basin, only eight wells have been sunk; namely, three at Goderich, two at Seaforth, two at Kincardine, and one at Clinton, besides what are being sunk at present, which will be referred to presently.

Wells sunk since 1869.

Some outside borings have proved that Dr. Hunt pretty accurately defined the northern limits of the basin, and sagaciously indicated its eastern boundaries and probable extension under the Corniferous and Hamilton formations to the south. In all the deep borings between Bruce and Essex counties, rock salt has been encountered.

Boundary of basin defined by Dr. Hunt.

Wells are now sunk deeper than at first; and a third stratum of rock salt has been reached, both at Seaforth and Goderich. Manufacturers find that the brine drawn from, or from immediately above the third stratum, is more uniform in strength than that from between the first and second strata.

Increased depth of wells.

In sinking the well for the "International" works, the driller, Peter McEwin,* said that he thought from the nature of the borings, he was close to a fourth bed of salt, when the work was stopped.

Mr. McEwin gave me the following record of this boring; specimens of the material bored through were forwarded to you, by the superintendent of the works:—

Log of well at the International works.

	FEET.
Blue clay, with a few limestone boulders	100
Limestone boulders and gravel	40
Alternate beds of sandstone and limestone	510
Hard, flinty limestone (1)	300
Blue shale, with thin streaks of red shale	84
Gypsum	6
Brown limestone (2), soft	14
Rock salt (No 1)	19
Brown limestone (2), very hard	30
Rock salt (No. 2)	24
Blue shale and blue clay	3½
Rock salt (No. 3)	32
Brown limestone (3), rather lighter in colour than the preceding	8
	1,170½

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* So many of the salt borings have been made by Peter McEwin, that he is distinguished by the sobriquet of "saltpetre."

(1) Corniferous and (2) magnesian limestone rocks.

Sixty feet of rock salt.

At Kincardine, which appears to be on the inside lip of the salt basin, the usual blue clays and shales are wanting, and the two salt beds are there united into one, forming a massive bed of pure rock salt, sixty feet thick.

In 1872, Messrs. Gray and Scott bought out the original proprietors of the Kincardine salt works, but after working the well for one season, they determined to sink another alongside, of increased dimensions and depth. This had been completed a few days before my arrival. The dimensions of the bore are eight and a half inches for 400 feet, and six and a half inches for the remaining 607 feet; the total depth being 1,007 feet, which is 110 feet below the previous boring. The following is the record, as given by the driller, J. S. McEwin:—

Log of new well at Kincardine.

	FEET.
Common sand	7
Yellow clay	8
Water gravel	10
Quicksand	64
Alternate layers of sandstone and limestone	28
Limestone	179
Very fine-grained white freestone	29
Dark colored limestone	276
Red shale	14
Blue shale	115
Very hard blue limestone	164
Very hard cherty rock	5
Rock salt	12
Alternate layers of blue shale and clay, mixed with salt	36
Hard and pure rock salt	60
Total	1,007

I could only get partial specimens of this and the Bruce well borings, which were enclosed with samples of brine and salt forwarded to your Department, by Mr. Thompson, Manager of the Bruce works.

No rock salt north of Kincardine.

Although the rock salt is so thick here, none has been found in any boring north of Kincardine.

To the south-west, borings were early made at St. Marys, London, Enniskillen, and Tilsonburg; but as no salt was found, no other borings were attempted. In this direction the well-borers had to contend with an enlargement of the Devonian series, and a thickening of the upper strata of the Onondaga formation. Dr. Hunt thought that valuable brines might be reached by deeper borings; and last year the well at

Tilsonburg was deepened from 854 to 1,450 feet. A brine of increased gravity was the result, which is now, I am informed, 50° to 60° by salometer; but no salt bed was reached, as they are evidently near its edge, but not over it. Tilsonburg is in the township of Dereham, and about seventy miles south-east of Seaforth. Further east, the Upper Silurian and Devonian series are separated by the outcrop of the Guelph formation, with axis bearing north. If the saliferous beds were found to the east of this, or near Burlington Bay, it would be a matter of much importance, owing to the ready accessibility there* to our eastern water front.

Well at Tilsonburg deepened.

The manufacturers of a low priced article like salt will naturally prefer, and necessarily seek for wells on the water front, where the facilities for moving fuel inwards and salt outwards are greater and cheaper. Cheaper freight enlarges their selling power, and gives them many advantages over inland wells, which are dependent on railway transportation. Hence we may look for more borings in future along the lake shores. And as the salt basin embraces the western counties of Essex, Kent, Lambton, Huron, and the south-western corner of Bruce, the water front of these counties promises to be the principal seat of our salt industry.

Situation of wells near the water front.

At Port Elgin, twenty miles, and Southampton, twenty-five miles further north, fruitless borings were made in 1869 and 1868 respectively; they have already been commented on by Dr. Hunt, as showing here the rise of the base of the Onondaga formation to the surface.

A well has since been sunk at Inverhuron, nine miles north of Kincardine, on the shore, between Port Elgin and and the latter place. The driller, J. S. McEwin, reports that the strata, for 895 feet, were identical with those at the Kincardine well, and that they then encountered blue shale and gypsum, slightly impregnated with salt; after which came Niagara shales, and at 1,007 feet, hard limestone, holding black water with an offensive odour.

Inverhuron.

At Teeswater, in the county of Huron, some twenty miles east, and a few miles north of the latitude of Kincardine, a gypso-saliferous bed, fifteen and a half feet thick, was struck, and found to yield a brine of 50° density. But although the hole was sunk to a depth of 1,180 feet, no rock salt was met with. The record and specimens of this boring were promised to me by Mr. Alexander Gibson, the President of the Company.

Teeswater.

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* From 1812 to 1816, or during the American war, Western Canada obtained its salt supplies from natural springs, at the head of Burlington Bay. It was designated "slush salt," from its imperfect manufacture; but no use, or mention is now made of it.

Ainleyville.

At Ainleyville, south-east of Teeswater, and fifteen miles north of Seaforth, a boring was made to 1,220 feet, with very similar results.

By these borings, the northern boundary of the salt basin has been pretty well defined.

Mitchell.

At Mitchell, eleven miles south-east of Seaforth, a well was bored to 2,008 feet. After passing through shales belonging to the base of the Onondaga formation, the Niagara limestones were reached, and at 1,570 feet, red shale 300 feet thick, belonging to the Medina formation.

Carronbrook.

At Carronbrook, midway between Mitchell and Seaforth, a well was sunk to a depth of 1,396¾ feet, without finding rock salt; but at 600 feet a gypso-saliferous marl was met with, yielding a brine of 40° strength, and after passing through this the Niagara limestones were reached. Being within five miles of Seaforth, the Company had been so confident of finding salt that works had been erected in advance. At the time of my visit, however, preparations were being made to bore another well, at a spot two miles east of Seaforth, the intention being to conduct the brine through log-piping to the works at Carronbrook. Seaforth is at present the most easterly point where rock salt has been found.

For the following information concerning localities which I have been unable to visit personally, I am indebted to Mr. P. McEwin:—

Information given by Mr. P. McEwin.

At Bayfield, twelve miles south of Goderich, a salt block had been erected, and a well was being drilled. At Port Frank, in the township of Bosanquet and county of Lambton, rock salt had been reached, and a block was in course of erection. At Warwick, in the same county, rock salt was found at 1,250 feet, and a Mr. Kingston had established salt works capable of turning out fifty barrels per day. The brine was of full strength, but contaminated by sulphur. At Dawn, in the county of Kent, Peter McEwin found rock salt at 1,100 feet, when boring for oil, but it was not turned to account.

PROSPECTIVE AND COLLATERAL INDUSTRIES.

It has already been mentioned, that the system of evaporating by steam is leading to the establishment in our salt territory of industries other than the manufacture of salt. We may look beyond this, to the gradual growth of various and extensive chemical works, which the progress of the country, and enterprise of its people, must soon render necessary.

Chemical works.

For these, enormous quantities of salt will eventually be required, while, at the same time, a demand will be created for other raw materials, especially for pyrites for the manufacture of sulphuric acid. The importance of salt for other than its more ordinary uses, with which we are familiar in this country, may be judged of from the fact that Great Britain annually consumes nearly 300,000 tons, or 12,000,000 bushels in her various manufactures.

But while we thus speculate on the prospective manufactures in which chloride of sodium is concerned, we must not lose sight of its value merely as *salt*; and whether we use it as a manure, an antiseptic, or a condiment, we have reason to be thankful that our supplies of it are in quality incomparable, and in quantity inexhaustible.

ENGLISH EXPORTS.

Beside her immense consumption of salt for manufacturing, domestic and agricultural purposes, England exports from seven to eight hundred thousand tons, or nearly thirty millions of bushels annually.

In 1873 and 1874 her salt exports were restricted by the unusually high prices of labour and coal.

British returns for 1872.

The following abstract is from the British returns for 1872, which year is taken as an average one.

Quantity of salt exported, 753,561 tons; the shipping value of which was £533,171 sterling. Of this there were exported to—

The Dominion	54,076 tons.
Newfoundland and Labrador	14,324 "
United States	154,010 "
Total to North America	222,410 tons,
	or 8,896,400 bushels.

AMERICAN SALT MANUFACTURE.

United States returns

The following condensed extracts are made from the annual returns of the United States, to show the increasing value of their salt industries:—

STATISTICS OF THE UNITED STATES SALT MANUFACTURE FROM 1850 TO 1870.

1850.

Capital employed	$2,640,885
Wages paid	$754,224
Value of salt made	$2,222,745

Number of hands employed, 2,776; quantity of salt made, 9,763,840 bushels; average price per bushel, 22¾ cents.

1860.

Capital employed	$3,692,215
Wages paid	$371,954
Value of salt made	$2,289,504

Number of hands employed, 2,213; quantity of salt made, 12,717,200 bushels: average price per bushel, 18 cents.

1870.

Capital employed	$6,561,615
Wages paid	$1,146,910
Value of salt made	$4,818,229

Number of hands employed, 2,953; quantity of salt made, 17,606,105 bushels; average price per bushel, 27⅓ cents.

I have the honor to be,

Sir,

Your obedient servant.

J. LIONEL SMITH.

GEOLOGICAL SURVEY OF CANADA,
MONTREAL, 1874.

TABLES

COMPILED BY

MR. J. LIONEL SMITH.

TABLE I.

DESCRIPTION OF SALT WORKS WITH WELLS.

Names of Wells or Works.		Location.	Proprietors.	Secretary or Manager.	President.	Depth of Well	Name of Driller.	Borings Completed.		Manufacture Commenced.	
						FEET.		MONTH.	YEAR.	MONTH.	YEAR.
A	Seaforth....	Seaforth ..	Coleman & Gouinlock	....	....	1,135	P. McEwin ...	....	1868	....	.....
B	Merchants ..	" ..	Joint Stock......	A. Armitage ..	M. P. Heyes ..	1,145	"	October ...	1870	May	1871
C	Eclipse	"	Grey, Young & Sparling	....	....	1,152	" ...	Nov'br	1870	" ...	1871
D	Stapleton. ..	Stapleton..	R. Ransford.	....	....	1,180	....	....	.....	....	.....
E	Clinton ...	Clinton..	McGarva, Coombe & Co..........	....	....	1,135	Lyman Bigelow	August...	1870	Sept'br...	1870
F	Goderich..	Goderich..	Joint Stock.. ...	Wm. Campbell.	John V. Detlor	1,002	P. McEwin ..	October ..	1866	March....	1867
G	Prince	" ..	" "	Closed 18 months	....	1,250	....	....	1868	....	.....
H	Maitland. ..	" ..	" "	S. H. Detlor....	....	1,000	....	....	1866	....	1867
I	Victoria	" ..	G. McKenzie...	....	....	1,110	....	....	1867	....	.....
J	Huron ...	" ..	Joint Stock.....	Closed 3 years...	James Dixon. .	1,100	....	....	1866	....	.....
K	Dominion. ..	" ..	" "	Geo. Cuttle....	....	....	....	....	.....	....	.....
L	Ontario.	" ..	" " ...	Wm. Kay.......	....	1,114	....	May......	1868	May.....	1868
M	Tecumseh	" ..	" " ...	Leased to George Neibeigall.....	....	1,128	P. McEwin. ..	....	1867	....	1867
N	Hawley's...	" ..	R. H. Hawley.	....	....	1,050	....	....	1871	....	1871
O	International	" ..	Joint Stock....	J. G. Robertson..	J. McCaughey.	1,132	P. McEwin....	May......	1874	June.....	1874
P	Rightmeyer's	Kincardine	L. Rightmeyer ..	....	....	975	M. Porter.....	Sept. 13...	1871	Sept'br...	1871
Q	Kincardine ..	"	Grey & Scott....	....	....	*1,007	J. S. McEwin.	August....	1868	Sept'br...	1868
R	Bruce	" ..	Joint Stock.. ..	Alex. Thompson.	G. D. Ferguson	†915½	M. Porter	June 13...	1870	January ..	1870

* The depth of the original well was 920 feet. A second boring, within a few feet of the first, was completed in June, 1874. The driller reports that he struck at 947 feet a solid bed of salt 60 feet thick.

† The original well was 900¾ feet deep. A second drilling completed April 30th, 1872, and passed below the former depth, through 7 feet of shale to a second bed of salt and then through 7¾ feet to a third bed.

TABLE II.

DESCRIPTION OF SALT WORKS WITHOUT WELLS.

	Names of Works.	Location.	Proprietors.	Names of Wells from which Brine or Salt is obtained.	Rent Paid for Brine.	Manufacture commenced.
S	Carter Bros'	Seaforth	Carter Bros.	Eclipse	$ 900 per annum.	July 13th, 1873.
T	Carter & Co.'s	"	J. J. Carter & Co	Eclipse	$1300 " "	July 1st, 1874.
U	Marshall's	"	W. Marshall	Merchants	$ 400 " "	July 5th, 1873.
V	Empire	Goderich	John McKenzie	Victoria	7c. per barrel	1872.
W	Stanley	"	J. Stanley	Dominion	8c. " "	1872.
X	Ogilvie's	"	A. W. Ogilvie	Hawleys	4c. " "	Com. next April
Y	Ogilvie's	Seaforth	A. W. Ogilvie	Eclipse	$700 per annum	" " "

Table-Salt Factories.

Platt's	Goderich	Samuel Platt	Tecumseh*		June, 1872.
Belfry's	Clinton.	J. Belfry	Stapleton*		1870.
Seaforth	Seaforth	Coleman & G.	Own Works*		1874.

* Salt.

TABLE III.

CAPACITY OF WORKS AND SYSTEM OF MANUFACTURE.

	Names of Works.	Number of Blocks.*	Number of Pans.	Horse-Power of Engines.	Daily Capacity in Barrels.	System of Evaporation.	Number of Furnaces	Dimensions of Pans.
	With Wells.							
A	Seaforth.....	3	4	30	450	English improved ‡(3)	3	2 of 100 x 24 feet each, and 1 of 132 x 28 ft.
B	Merchants ...	2	2	25	300	Heye's patent.....(6)	2	110 x 24, and 128 x 24 ft.
C	Eclipse......	1	1	25	100	Runsiman method.(5)	1	100 x 20 ft.
D	Stapleton....	1	3	....	250	English improved...	3	40 x 22 ft. each.
E	Clinton......	1	2	12	100	English do (2)	2	40 x 22 ft. each.
F	Goderich.....	1	2	16	250	Platt's patent.....(4)	2	100 x 12 ft. each.
G	Prince... ...	1	3	16	125	English............	....	1 of 100 x 12 ft., and 2 of 50 x 12 ft.
H	Maitland.....	1	2	15	150	Platt's patent........	2	96 x 12 ft., and 50 x 12 ft.
I	Victoria.....	1	3	12	80	do do	2	50 x 12 ft. each.
J	Huron........	1	Kettles.	16	Closed 1870	Syracuse method..(1)	....	104 kettles, each to hold 140 galls.
K	Dominion....	1	3	30	180	English improved ...	2	40 x 22 ft. each.
L	Ontario......	1	2	12	150	do do ...	2	40 x 22 ft. each.
M	Tecumseh ...	1	2	16	300	Platt's patent	2	100 x 12 ft., and 50 x 12 ft.
N	Hawley's....	1	1	16	200	Copper pans.... .(7)	....	40 x 10 ft.
O	International	1	4	45	800	Heye's patent......	4	100 x 20 ft. each.
P	Rightmeyer's	1	1	20	350	do do	3	130 x 25 ft.
Q	Kincardine...	2	2	25	500	do do	3	174 x 28 ft., and 110 x 24 ft.
R	Bruce.......	1	1	20	150	English improved ...	2	107 x 18 ft.

S	*Without Wells.*							
S	Carter Bros'..	1	1	None.	150	Runciman method...	1	50 x 20 ft.
S	Carter & Co's	1	1	"	180	do do ...	2	115 x 20 ft.
U	Marshall's..	1	1	"	30	Wooden vats.....(8)	....	80 x 14 ft. x 12 inch, and 2 rows of 4 in. pipes.
S	Empire.....	1	1	"	50	Platt's patent.......	2	96 x 10 ft.
W	Stanley.....	1	3	"	150	Runciman method...	1	40 x 22 ft. each.
X	Ogilvie's, Goderich	1	2	"	150	Wooden vats........	....	120 x 22 ft. each, 1 row 6 in. brass pipe and 152 half-inch cross pipes.
Y	Ogilvie's, Seaforth.	1	1	"	75	do do........	....	90 x 22 ft., 6 in. pipe round bottom, and 112 half-inch cross pipes.

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[*] A Block is a building or factory complete in itself, with all the appurtenances for manufacturing.

[‡] These numbers represent the order in which each system came into use.

(1.) *Syracuse Method.*—Kettles or spherical pans are employed, each containing about 140 galls. of brine, and arranged in parallel rows of fifty or more, with one or two rows to each block. Kettles may answer for weak brines, but were found so wasteful and unfit for the heavy brines of Ontario, that they were soon abandoned. Incrustation so rapidly accumulated on them, that much heat, salt, labour and time were lost thereby.

(2.) *English System.*—In this system Iron Pans are used, the dimensions of which are 40 x 22 ft., with rectangular sides. The salt is taken out of them by means of deep wooden boxes, which are placed on the bottom of the pan and filled by shovels. This system is also distinguished by its numerous fire-places and flues for the distribution of heat. Each block has two or three furnaces in front, with their flues carried back under the pans, in zig-zag or other form, for retention of heat

(3.) *English Improved System.*—This differs mainly from the previous one in the employment of pans with sloping or oblique sides—now common in other systems—up which the salt can be easily and quickly drawn.

(4.) *Platt's Patent.*—In this system, a tubular boiler is placed below the pan, and the steam from this is superheated, and fills a chamber directly under the evaporating pan Very rapid evaporation is caused by the heat given out by the steam as it condenses. The water produced flows back into the boiler. The advantages claimed for this patent are equality of heat, by which salt of a uniform grain is made, economy of fuel, reduction of scale on pans, and a saving of labour. It also claims to make 65 to 70 bushels of salt for every cord of wood burned.

(5.) *Runciman System.*—This is often designated "the double enders," from having its fire-places and chimnies at both and alternate ends. In this, the pans are the same as in the English system; but the chimney and fire ends of each flue are reversed, and there are hot air chambers under each pan. A great uniformity of heat is the result.

(6.) *Heyes' Patent System.*—This is in use at four of the largest salt works. There are "patent heaters" running along the bottom and sides of the furnace, through which the brine flows and is heated, before reaching the pans, depositing at the same time gypsum, or other impurities. It is claimed that salt made according to this system is very pure, and that owing to the equal heat a uniformity of crystallization is ensured. About 75 bushels of salt are produced to the cord of wood.

(7.) *Copper Pans.*—These were supposed to be necessary at Hawley's well, owing to the corrosive character of the brine, which rapidly eats away iron, causing the salt to be tinged red. Although the copper pans are better radiators of heat, this does not compensate for their cost.

(8.) *Wooden Vats.*—In these steam-piping is the only metallic surface in contact with the brine. They are apparently best adapted for the strong brines of Ontario. Their use is fully explained, and their merits discussed in another place.

TABLE IV.

CAPITAL AND LABOUR EMPLOYED IN 1874.

	Names of Works	Value of Plant.	Value of Works.	Capital Invested.	Hands Employ'd.	Wages per Day.	Days per Month.	Wages paid per Month.	Months Working.	Wages paid per Season.
	With Wells.	$	$	$		$		$		$
A	Seaforth	15,000.00	40,000.00	50,000.00	33	1.35	26	1,158.30	8	9,266.40
B	Merchants	10,000.00	35,000.00	45,000.00	26	1.35	"	912.60	8	7,300.80
C	Eclipse	1,915.00	10,000.00	15,000.00	15	1.30	"	507.00	9	4,563.00
D	Stapleton	8,000.00	33,123.00	45,000.00	....	....	....	......	....	......
E	Clinton	5,000.00	8,000.00	12,000.00	11	1.25	"	357.50	4	1,430.00
F	Goderich	12,000.00	20,000.00	25,000.00	15	1.37	"	534.30	7	3,740.10
H	Maitland	5,000.00	15,000.10	20,000.00	20	1.35	"	702.00	7	4,914.00
I	Victoria	5,800.00	12,000.00	15,000.00	15	1.35	"	526.50	7	3,685.50
K	Dominion	3,000.00	15,000.00	20,000.00	14	1.35	"	491.40	5	2,457.00
L	Ontario	....	17,500.00	23,000.00	10	1.30	"	338.00	4	1,352.00
M	Tecumseh	8,000.00	20,000.00	30,000.00	17	1.32	"	583.44	7	4,084.08
N	Hawley's	10,000.00	20,000.00	35,000.00	12	1.38	"	430.56	4	1,722.24
O	International	25,000.00	50,000.00	100,000.00	40	1.38	"	1,435.20	6	8,611.20
P	Rightmeyer's	15,000.00	30,000.00	40,000.00	25	1.35	"	877.50	7	6,142.50

Q	Kincardine.............	20,000.00	30,000.00	45,000.00	20	1.35	26	702.00	7	4,914.00
R	Bruce	8,000.00	20,000.00	35,000.00	25	1.35	"	877.50	7	6,142.50
	Without Wells.									
S	Carter Bros'	2,500.00	5,000.00	10,000.00	15	1.30	"	507.00	7	3,549.00
T	Carter & Co.'s...........	3,500.00	6,000.00	12,000.00	17	1.30	"	574.60	7	4,022.20
U	Marshall's	1,000.00	2,000.00	5,000.00	5	1.30	"	169.00	9	1,521.00
V	Empire..................	2,500.00	4,000.00	8,000.00	10	1.28	"	332.80	7	2,329.60
W	Stanley.................	2,500.00	5,000.00	10,000.00	17	1.33	"	587.86	7	4,115.02
X	Ogilvie's, Goderich.	Works not completed.								
Y	" Seaforth.									

Table-Salt Factories.

Platt's..................	....	3,000.00	8,000.00	3 12*	1.25 0.25	"	175.50	9	1579.50
Belfry's.................	....	3,000.00	6,000.00	3	1.30	"	101.40	9	912.60
Seaforth.................	....	4,000.00	10,000.00	4	1.25	"	130.00	9	1,170.00
	$163,715.00	$408,123.00	$624,000.00						$89,524.24

* Children.

TABLE V.

QUANTITY AND VALUE OF SALT MADE IN THE YEARS 1872 AND 1873.

	Names of Works.	Manufactured in 1872.	Price per Barrel.	Total Value.	Manufactured in 1873.	Price per Barrel.	Total Value.	Land Salt, average Make per Years 1872 & 1873.	Price per Ton.	Total Annual Value.
		*	c.	$		$	$	TONS.	$	$
A	Seaforth......	36,500 Brls.	85	31,025.00	51,0 6 Brls.	.96	49,032.96	500	2.75	1,375 00
B	Merchants.....	45,000 "	85	38,250.00	50,000 "	.95	47,500.00	335	"	921.25
C	Eclipse.......	19,000 "	85	16,150.00	22,000 "	.93	20,460.00	180	"	495.00
D	Stapleton.....	35,682 "	81$\frac{4}{10}$	29,045.15	40,000 "	.90	36,000.00	300	"	825.00
E	Clinton.......	5,000 "	82	4,100.00	10,000 "	.86	8,600.00	65	"	178.75
F	Goderich	20,000 "	90	18,000.00	22,000 "	1.00	22,000.00	150	"	412.50
H	Maitland	20,000 "	90	18,000.00	20,000 "	1.05	21,000.00	150	"	412.50
I	Victoria......	8,500 "	90	7,650.00	10,000 "	1.00	10,000.00	50	"	137.50
K	Dominion.....	16,952 "	86	14,578.72	21,500 "	.95	20,425.00	180	"	495.00
L	Ontario.......	20,000 "	85	17,000.00	20,000 "	1.00	20,000.00	125	"	343.75
M	Tecumseh	20,000 "	85	17,000.00	20,000 "	1.00	20,000.00	125	"	343.75
N	Hawley's	10,000 "	86	8,600.00	18,000 "	1.00	18,000.00	55	"	151.25
P	Rightmeyer's....	20,000 "	86	17,200.00	40,000 "	1.00	40,000.00	250	"	687.50
Q	Kincardine....	20,000 "	86	17,200.00	26,000 "	1.00	26,000.00	200	"	550.00
R	Bruce	14,000 "	86	12,040.00	21,000 "	1.00	21,000.00	100	"	275.00
S	Carter Bros'...	....	......	....	†23,000 "	.90	20,700.00	100	"	275.00
U	Marshall's....	....	......	....	†6,000 "	.95	4,800.00	....	"	....
V	Empire.......	6,000 "	86	5,160.00	6,000 "	.95	5,700.00	25	"	68.75
W	Stanley	23,000 "	85	19,550.00	25,000 "	1.00	25,000.00	150	"	412.50
	Totals.......	339,634 Brls.		$ 280,548.87	451,576 Brls.		$ 436,217.96	3,040 tons.		$ 8,360.00

* Five bushels allowed to the barrel.

† Made from July, 1873, to July, 1874.

TABLE VI.

Proportion of Fine and Coarse Salt made, with proportions shipped in bulk and proportions sold in Canadian and United States markets, in the year 1873

	Names of Works.	Fine in Barrels.	Coarse in Barrels.	Proportion shipped in bulk.	Sold in Canada.	Sold in the United States.
				*	In bbls.	In bbls.†
A	Seaforth	48,076	3,000	1/5	46,576	4,500
B	Merchants	45,000	5,000	1/6	46,500	3,500
C	Eclipse	21,500	500	......	22,000	....
D	Stapleton	39,000	1,000	......	40,000	....
E	Clinton	9,500	500	......	10,000	....
F	Goderich	22,000	....	1/2	5,000	17,000
H	Maitland	20,000	....	1/2	6,000	14,000
I	Victoria	10,000	....	1/3	2,000	8,000
K	Dominion	21,000	500	2/3	3,500	18,000
L	Ontario..................	19,500	500	1/2	....	20,000
M	Tecumseh	20,000	....	3/4	2,000	18,000
N	Hawley's..................	18,000	....	3/4	....	18,000
P	Rightmeyer's............	40,000	....	3/4	2,000	38,000
Q	Kincardine	26,000	....	3/4	2,000	24,000
R	Bruce	20,500	500	1/2	3,000	18,000
S	Carter's......	22,000	1,000	......	23,000	....
U	Marshall's..............	6,000	....	......	6,000	....
V	Empire..................	6,000	....	3/4	2,000	4,000
W	Stanley..................	24,000	1,000	3/4	5,000	20,000
		438,076	13,500		226,576	225,000

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* The proportions in this column represent bulk shipments to the United States. Very little salt being shipped in bulk to Canadian markets, it scarcely deserves notice.

† Shipments to the United States are here all given in barrels, for convenience in comparison.

TABLE VII.

CONSUMPTION OF WOOD IN 1873.

	Names of Works.	Cords of Fire-wood.	Price per Cord. *	Total Cost.
			$	$
A	Seaforth ……	5,500	3.00	16.500.00
B	Merchants ….	4,500	3.00	13,500.00
C	Eclipse …….	1,850	3.00	5,550.00
D	Stapleton …..	4,500	2.50 †	11,250.00
E	Clinton …….	2,000	2.75	5,500.00
F	Goderich……	2,500	2.75	6,875.00
H	Maitland……	2,300	2.75	6,325.00
I	Victoria ……	1,500	2.75	4,125.00
K	Dominion…..	1,935	2.75	5,321.25
L	Ontario …….	2,100	2.75	5,775.00
M	Tecumseh …..	3,000	2.75	8,250.00
N	Hawley's……	2,000	2.75	5,500.00
P	Rightmeyer's…	4,500	3.00	13,500.00
Q	Kincardine…..	3,500	2.75	9,625.00
R	Bruce………	2,200	2.75	6,050.00
S	Carter Bros.'…	2,000	3.00	6,000.00
U	Marshall's…..	500	3.00	1,500.00
V	Empire …….	800	3.00	2,400.00
W	Stanley …….	3,000	2.75	8,250.00
	Belfry's…….	200	2.75	550.00
	Platt's……..	250	3.00	750.00
	Total………	50,635	……..	$143,096.00

Names of Cooperages.	Locality.	Cords of Bolts for Barrels.	Price per Bolt.	Total Value.
			$	$
Vollmer's……	Seaforth ……	1,500	3.00	4,500.00
Eclipse …….	" …..	1,500	3.00	4,500.00
Ament's…….	" ……	1,200	3.00	3,600.00
Ransford's…..	Clinton…….	1,200	3.00	3,600.00
Tecumseh…..	Goderich……	1,250	3.00	3,750,00
Bruce ……..	Kincardine….	1,750	3.00	5,250.00
				$25,200.00

There are other cooperages in the salt district, but the above are the principal ones. A large proportion of the barrels made by them are for flouring-mills, which also abound in the district. Barrels made at the Bruce Cooperage are mostly for flour.

Salt barrels are made heavier than flour barrels. Forty of the former, or fifty-five of the latter, are made from a cord of bolts. The proportion made of each could not be ascertained.

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[*] The price of good hard wood was $3.00 per cord, and of soft wood $2.25 per cord. As both kinds were occasionally used at most of the works, the price is, in some instances, averaged.

[†] Messrs Ransford own large tracts of wood-land, and are consequently sellers, and not buyers of wood. They debit themselves with good hard wood at $2.50 per cord.

NOTES

ON

A FEW CANADIAN MINERALS AND ROCKS.

BY

B. J. HARRINGTON, B.A., PH.D.,

ADDRESSED TO

ALFRED R. C. SELWYN, ESQ., F.R.S., F.G.S.,

DIRECTOR OF THE GEOLOGICAL SURVEY OF CANADA.

Introductory note.

SIR,—I have the honour to submit to you a small contribution towards our knowledge of Canadian minerals and rocks. The majority of the facts given can scarcely be said to be of general interest; but it must be borne in mind that a great deal of light is often thrown upon economic mineralogy by the study of minerals possessing no intrinsic value whatever. This, indeed, must be my excuse, if an excuse be necessary, for presenting the following notes.

Aluminous Pyroxene.

Characters of pyroxene from Grenville.

Associated with mica (phlogopite) and calcite, at the Grenville mica mines, and forming the largest proportion of the deposits from which the mica is derived, is an interesting variety of pyroxene. Its predominant colour is pale greenish-grey; but this passes on the one hand into greyish-white, and on the other into dark greenish-grey. It is massive crystalline, and often affords cleavage planes several inches in length and breadth. Crystals are also common, and are occasionally five or six inches in length, and from one to two inches in thickness. The planes of the rhombic prism are sometimes almost wanting, but are more frequently well developed, producing eight-sided prisms, which are often tapering, and which were formerly known to the miners as "teats." They frequently penetrate the plates of mica, rendering them useless. The pyroxene is opaque to translucent, and has an uneven fracture; the lustre is vitreous, or frequently resinous. An analysis of a specimen, of a pale greenish-grey colour, with a hardness of 5, and specific gravity of 3·35, gave the following results:—

Silica	51·27
Alumina	4·00
Ferric oxide	0·10
Lime	25·27
Magnesia	17·46
Potash	0·14
Soda	0·62
Lithia	traces.
Water (ign.)	1·63
	100·49

Regarding the alumina as replacing silica, we find that the ratio of the oxygen in the silica and alumina to that in the protoxide bases, is nearly 2: 1. The mineral may then be correctly termed an aluminous diopside.

Pyroxene as a constituent of Laurentian rocks.

The occurrence of pyroxene as a constituent of Laurentian rocks has been repeatedly noticed in the reports of the Survey, and Dr. Hunt has shown (Geol. of Can., 1866, p. 207) that one or other of the varieties diopside, sahlite, or coccolite, often forms the predominant mineral of Laurentian veinstones. An aluminous pyroxene from Burgess, which he examined many years ago, does not differ essentially in composition from the one just described; and this is but one of the many points of resemblance between the minerals of the Burgess and Grenville regions.

Sodalite, Natrolite and Analcite.

Dykes cutting the Trenton limestones.

At what is known as the Montreal reservoir extension, the Trenton limestones are cut by numerous dykes, the more recent of which consist of fine-grained dolerites, or anamesites, while the more ancient ones are apparently composed largely of feldspar, with, in some instances, more or less hornblende.* One of the latter, varying in colour from fawn-colour to lavender-grey and greyish-brown, and containing a good deal of hornblende, and small quantities of iron pyrites, has afforded specimens of sodalite, natrolite and analcime. The sodalite is found in small, irregular crystalline masses, scattered through portions of the dike, and appears to have crystallized contemporaneously with the feldspar and hornblende, while the natrolite and analcime have evidently been deposited subsequently on the walls of cavities. **Sodalite.**

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* These dykes require further study. Some of them were, many years ago, described by Hunt, under the name of trachytes; but they differ essentially from the rocks ordinarily called trachytes. The one containing the sodalite is often porphyritic, with crystals of feldspar.

The sodalite varies in colour from white to azure blue; it is translucent to sub-transparent, and has a vitreous lustre; the cleavage is dodecahedral, and the fracture uneven, or sometimes conchoidal; the hardness is 5·5, and the specific gravity 2·22. The material for the following analysis was dried at 100° C:—

Silica	37·52
Alumina	31·38
Ferric oxide	trace.
Lime	0·35
Magnesia	trace.
Soda	19·12
Potash	0·78
Sodium	4·48
Chlorine	6·91
	100·54

A separate portion of the mineral lost on ignition one per cent. It is readily decomposed by hydrochloric or nitric acid, with separation of gelatinous silica. Before the blowpipe it fuses (fusibility almost 4) with slight intumescence to a colorless glass. In the closed tube the blue variety turns white.*

Natrolite. The natrolite occurs in slender, almost acicular crystals, often interlacing, and in groups of less perfect radiating crystals. It is colourless to white, and has a vitreous lustre, inclining to pearly in the case of the radiating crystals. The hardness is 5, and specific gravity 2·22. An analysis gave the following results :—

Silica	47·40
Alumina	26·38
Lime	0·48
Soda	16·48
Potash	0·57
Water	9·75
	101·06

---

* Since the above was written, sodalite in considerable quantity has been detected in a similar rock forming part of Belœil mountain. The occurence of sodalite in the "granitoid trachyte" of Brome was observed by Hunt many years ago.

Analcite.

Analcite is almost invariably associated with the natrolite in small, white, translucent crystals, averaging about an eighth of an inch in diameter. It seems to be much more liable to decomposition than the natrolite, and is often altered to a dull white substance, which, in some cases, retains the form of the trapezohedron. When in this altered condition it forms a fine background for the glassy crystals of natrolite.

Chromiferous Serpentine.

Associated with chromic iron, in the townships of Bolton and Melbourne, there occurs a mineral which has long been supposed to be kämmererite—a mineral related in chemical and optical characters to penninite. A specimen recently examined, however, has rather the composition of an aluminous serpentine. It is massive, or slightly foliated; greasy to somewhat pearly in lustre, and translucent to subtranslucent; the colour is pale violet by reflected, andsomewhat deeper violet by transmitted light; feel almost as greasy as that of talc; hardness only 2. The specimen analyzed was found to contain,

Analysis of serpentine.

Silica	43·94
Alumina and ferric oxide	5·69
Chromic oxide	0·67
Lime	1·22
Magnesia	34·80
Water	14·54
	100·86

In appearance the mineral resembles some of the varieties of kämmererite from Texas, Pennsylvania. The latter mineral, however, contains much less silica, and a far larger proportion of alumina.

Pyrrhotite or Magnetic Pyrites, and the Minerals associated with it at Elizabethtown, Ontario.

On the nineteenth lot of the second range of Elizabethtown, there occurs in rocks of Laurentian age an important deposit of pyrites (see Geol. of Can., 1863, p. 747), which has long been known, and has been mined for several years by the Brockville Chemical and Superphosphate Company. It is not only of economic importance, but also of scientific interest, on account of the association of minerals which it contains. The minerals number about a dozen species, being pyrite, pyrrhotite, magnetite, quartz, talc, labradorite (?) phlogopite (?) a black hydrated silicate of iron

List of minerals occurring at Elizabethtown.

alumina and magnesia, somewhat resembling hisingerite in appearance, calcite, siderite, apatite and cacoxenite. The variety in the composition of these minerals is worthy of note, there being sulphides, oxides, anhydrous and hydrous silicates, carbonates and phosphates (anhydrous and hydrous). Another curious aggregate, in some respects resembling the above, may be cited here. It was mentioned in the *Report of Progress* for 1873-'74, p. 194, and occurs on the sixth lot of the eighth range of Marmora. The minerals are pyrite, pyrrhotite, chalcopyrite, magnetite, fluorite, feldspar, hornblende, siderite and calcite. These deposits are possibly both veins, but differ in their constituents from any of those hitherto observed in the Laurentian.

Curious mineral aggregate in Marmora.

Of the minerals occuring at Elizabethtown, pyrite and calcite are the most abundant. The former is generally massive and amorphous, but is sometimes well crystallized, the most common form being a combination of the cube and octahedron. Perfect octahedra, with the axes more than two inches in length, have also been obtained, and mammillary groupings of cubical crystals with rounded faces occasionally occur. According to the determinatious of Hunt and Macfarlane,* the massive brilliant pyrites contains from 0·50 to 0·60 per cent. of oxide of cobalt.

Description of the Elizabethtown deposit.

Cobalt.

Calcite forms the principal gangue in which the other minerals are embedded. It is mostly massive, but is also found on the walls of cavities in rhombohedral crystals, which are often highly modified. It ranges from opaque to transparent, and varies much in colour, being white, grey, pale fawn-colour, and sometimes red. The black hydrated silicate alluded to above has been examined by Mr. Hoffmann, and an analysis of it will be found in his report. It frequently forms the gangue of the pyrites, and with it is occasionally associated a triclinic feldspar, showing a beautiful play of colours. Magnetite is rather common, and sometimes occurs in the form of irregular grains scattered through the calcite. The rare mineral cacoxenite is a hydrous phosphate of iron—generally regarded as an iron-wavellite. At Elizabethtown it occurs in the form of beautiful little yellow tufts on the walls of cavities in the calcite, and is generally accompanied by pyrite. It has not been quantitatively analyzed, but was found to be soluble in hydrochloric and nitric acids, and to contain iron and phosphoric acid.

Cacoxenite.

The quartz, mica, talc, siderite and apatite were only observed in small quantity. The talc is mainly in the form of steatite, some of which occurs in curious honey-combed masses. The cavities have

Steatite.

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* Geol. of Can., p. 506, and Can. Nat., 1st ser., vol. vii., p. 194.

probably been filled at one time with some mineral which has since been removed, and in a few instances loose pieces of quartz were found in them. The occurrence of steatite in the Laurentian series is, according to Hunt, uncommon, its place being generally taken by pyrallolite.

Pyrrhotite.

Pyrrhotite was common in portions of the deposit worked several years ago, but seems to have become less so as the mining advanced. It is sometimes massive, but more frequently occurs in acute rhombohedral crystals, varying in length from a quarter of an inch or less, up to several inches, and generally embedded in calcite, though sometimes in steatite. Facing this page is a drawing of a very interesting twin crystal, by Mr. Arthur H. Foord, Artist to the Survey. It was found several years ago, and has been examined by Mr. Edward Dana, of New Haven, who has kindly promised to describe it in the American Journal of Science. The following is an analysis of a portion of another crystal about an inch in diameter:—

Iron	60.560
Copper	0.145
Manganese	0.060
Nickel	0.112
Cobalt	0.11
Sulphur	39.020
Silica	0.036
	100.044

The mineral is readily attracted by the magnet, and possesses polarity; the opposite poles being situated not at opposite ends of the crystals, but along the sides. The hardness is between 3½ and 4, and the specific gravity 4.622.

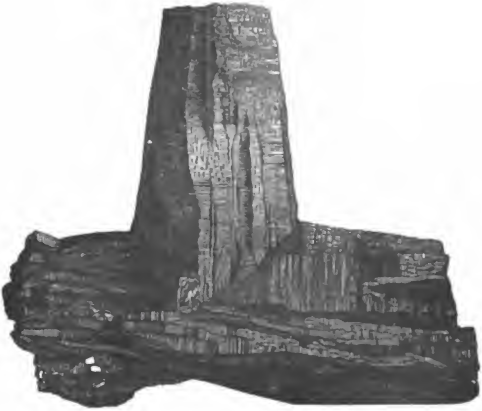
Since the above analysis was made, a small crystal of the pyrrhotite was sent to Professor J. Lawrence Smith, of Louisville, Kentucky, who was anxious to compare its composition with that of troilite, the sulphide of iron occurring in meteorites. The results of Professor Smith's analysis are as follows:—

Analysis by Professor Smith.

Iron	59.88
Sulphur	39.24
Silica (gangue-rock)	1.01
	100.13
Specific gravity	4.642

Troilite.

Both the analyses agree far more closely with the formula $Fe_7 S_8$, than with that of troilite, Fe S, which gives iron 63·64, sulphur 36·36.



TWIN CRYSTAL OF PYRRHOTITE FROM ELIZABETHTOWN, ONTARIO.
(Natural size.)

A. H. FOORD, del.

To face page 306.

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Manufacture of Acids at Elizabethtown, and of Superphosphate of Lime at Brockville, Ontario.

Site of acid works.

The deposit just described has, as stated above, been mined for several years, and is of importance as being the source from which considerable quantities of pyrites have been derived for the manufacture of sulphuric acid. The present acid works of the "Brockville Chemical and Superphosphate Company" are situated close to the pyrites mine, and were completed in 1874. Acid works had previously been built by the same company at Brockville in 1869, but were destroyed by fire in 1871. The capacity of the works at Elizabethtown is about six thousand pounds of sulphuric acid (66° Beaumé) daily. The final concentration is carried on in glass retorts, of which there are thirty-two, arranged in two rows and heated with anthracite. According to the manufacturers, the acid as it comes from the chambers, varies in strength from 45° to 48° Beaumé (=Sp. gr. 1·45 to 1·49); by evaporation in leaden pans it is raised to from 60° to 62° B. (Sp. gr. 1·71 to 1·75), and the strength of the retort acid is about 66° B. (Sp. gr. 1·84).* The nitrate of soda employed is obtained from Boston, and costs, laid down at the works, about 4½ cents per pound. Formerly nitre was imported from England, but was much more expensive. The pyrites yields, on an average, about forty per cent. of sulphur, and a ton of pyrites makes nearly a ton of acid. The acid sells for about 2½ cents per pound; some of it is employed in the manufacture of superphosphate of lime at Brockville, while the remainder is shipped to different parts of Canada and the United States. In addition to sulphuric acid, both hydrochloric and nitric acids are being made, and the establishment of other manufactures depending directly or indirectly upon sulphuric acid—such, for example, as that of soda—is probably not far distant. †

Hydrochloric and nitric acids.

The superphosphate works at Brockville were started in 1869, but since then many additions have been made to them. The apatite employed is from the township of North Burgess, and is stated to contain an average of about eighty per cent. of phosphate of lime. It is first broken up by a small Blake's rock-breaker, then crushed between iron rollers, and, after passing through a series of sieves, to free it from mica, ground between ordinary millstones. The ground mineral is then mixed

Manufactur superphosphate.

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* The specific gravities here given as corresponding to degrees of Beaume's hydrometer are according to Poggiale.

† The growing importance of pyrites in the manufacture of sulphuric acid may be judged of from the quantities consumed in England and France. In England, according to the *Comptes Rendus*, the consumption has increased in the last ten years from 180,000 to 520,000 tons annually; while, in France, during the same period, it has increased from 90,000 to 180 000 tons.

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in an *agitator* with an equal weight of sulphuric acid (50° B.), and the mixture afterwards emptied into a car, from which it is dumped into a series of boxes or bins, where it soon solidifies into white honeycombed masses of superphosphate, containing, according to the manufacturers, as high as twenty per cent of soluble phosphoric acid. The superphosphate is then broken or ground up in a *Carr's disintegrator*, and put into barrels for shipment. The price at Brockville is $30.00 per ton of 2,000 lbs.

Both the acid and superphosphate works are under the management of Alexander Cowan, Esq., of Brockville, who has shown much skill and perseverance in their establishment.

Use of artificial manures.

The use of artificial manures is something to which the majority of our farmers are wholly unaccustomed, and it will, no doubt, be long before their application will become general; but considering the exhausted condition of the soil in many parts of the country, the subject is one demanding most careful attention. It must, however, be kept in mind that the indiscriminate use of such manures is not to be recommended. They should be used intelligently; for the wants of a soil in one region may be entirely different from those of another, and the food which nourishes one plant may not be required by another.

Magnesitic Ophiolite.

It is well known that among the metamorphic rocks of the Eastern Townships serpentines or ophiolites are of common occurence, and it was many years ago shown by Hunt that while some of them are nearly pure, massive serpentines, others are mixtures of this mineral with carbonate of lime and dolomite. For these mixtures Hunt suggested the names *calcitic ophiolite* and *dolomitic ophiolite*, while the corresponding rock, consisting of serpentine and magnesite, he styled *magnesitic ophiolite*. The last-named variety was not then known to occur in the Eastern Townships, although it had been detected by Drs. Jackson and Hayes among the rocks of Vermont. Recently, however, an ophiolite from the fifteenth lot of the first range of Melbourne has been analyzed and found to be magnesitic—the magnesite being the ferriferous variety known as breunnerite. This mineral is scattered through the serpentine in small irregular crystalline masses of a pale brown colour, constituting 15·50 per cent. of the specimen examined. It was separated from the serpentine by means of dilute nitric acid, and gave on analysis:—

Magnesitic ophiolite from Melbourne.

Carbonate of magnesia	83.23
Carbonate of lime	1.93
Ferrous carbonate	14.84
	100.00

The residue, constituting 84.5 per cent of the rock, consisted of serpentine containing chromium, manganese, nickel, and cobalt. Its quantitative analysis gave the following results:—

Silica	42.79
Chromic oxide	0.29
Oxides of nickel and cobalt	0.37
Manganous oxide	0.12
Ferrous oxide	6.05
Magnesia	36.54
Water (ign)	13.37
	99.53

In the mass the serpentine is of an olive-green colour, and has a splintery fracture. Its hardnes is about 4.[*]

The Feldspars of some of the Diorites of Ontario.

Oligoclase.

In my last report (Report of Progress, 1873-74, p. 198), reference was made to the diorites which are of frequent occurrence among the metamorphic rocks of Ontario, and are often accompanied by magnetic iron ore. It was also shown that the feldspar in a coarsely crystalline variety at the Fournier iron mine, in South Sherbrooke, was closely related in composition to oligoclase. Since then analyses have been made of the feldspars in diorites from two other localities, and not only were they found to differ from one another in composition, but neither of them could be referred to oligoclase. One of them is from "Hole in the Wall,"[†] in Tudor, and was collected by Mr. H. G. Vennor, in 1866. It is of a pale greenish-grey colour, mostly dull, though here and there exhibiting crystalline faces which have a vitreous lustre, and are occasionally striated. Weathered surfaces are of a pale rust-colour, but this may be due to the oxidation of pyrites, small grains of which are scattered through the rock. The hardness is a little above 6, and the specific gravity, 3·02. Before the blowpipe it fuses (fus. above 4) on the edges to a greenish glass. The composition was found to be as follows:—

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[*] It may be stated here that specimens of the so-called serpentines from Cape Breton mentioned on page 9 of your Summary Report, were given me by Mr. Robb for examination, but proved not to be serpentines at all. They contain small quantities of a soft steatitic mineral in the joints which, no doubt, caused them to be mistaken for serpentines.

A supposed serpentine from the shore about two miles from Malignant Cove (near Arisaig, N.S.), was found to be simply a diorite with serpentine filling its joints. Another rock, which it was thought might be serpentine, was given me by Professor Bell for examination. It came from Dog Island, Lake Nipigon, and its mode of occurrence has already been described (Rept. for 1871-72, p. 104). It was found to contain nearly thirty per cent. of carbonates of lime and magnesia. The residue, insoluble in dilute nitric acid, after being dried at 100° C., contained 70.84 per cent. of silica and only 2.5 per cent. of water, and is therefore evidently not serpentine.

[†] A sort of defile passing through a great wall or cliff of rock

Analysis of feldspar related to anorthite.

Silica	47·29
Alumina	26·98
Ferric oxide	3·11
Ferrous oxide	0·91
Lime	14·20
Magnesia	0·66
Soda	4·64
Potash	0·06
Water (ign)	1·90
	99·75

The finely powdered mineral was found to be attacked by hydrochloric acid, which in one experiment dissolved 14·64 per cent. The high specific gravity and the composition appear to indicate that the feldspar is impure; but it may, perhaps, be referred to anorthite, and classed with the variety known as Bytownite. The oxygen ratio for the protoxide bases, sesquioxide bases, and silica, is 1: 2·36: 4·40; while that of the Bytownite from Ottawa, analyzed by Hunt, is 1: 2·63: 4·69.

Tudor diorite.

The hornblende of the Tudor diorite is of a dark olive-green colour, and much more highly crystalline than the feldspar. The texture of the rock moreover, is very coarse; far coarser, indeed, than is usual with the diorites of the region in question. The specimens examined bear no marks of stratification, but Mr. Vennor has shown me others from the same cliff in which the lines of bedding are distinctly visible.

Labradorite described by Mr. Hoffmann.

The other specimen referred to is from a coarsely crystalline diorite (one of Mr. Vennor's so-called "blotched diorites") which occurs on the sixteenth lot of the third concession of North Sherbrooke. It is a genuine labradorite, and will be described by Mr. Hoffmann in his report. Mr. Vennor has also described, in his report, rocks which he regards as forming a transition from diorite to syenite, and which he has called syenitic diorites; but no analyses of the supposed orthoclase in these rocks have been made, so that the matter cannot be regarded as certain.

Orthoclase.

Limestone, Dolomite, and Marl.

Some time since a specimen of limestone from the twenty-second lot of the third range of Wickham (E. T.), was left at the Geological Survey Office for examination its owner, Mr. Touseant Garriepie, of Drummondville, being anxious to ascertain whether it might be expected to yield a hydraulic lime on burning. The limestone is blackish-grey in colour, and has a somewhat conchoidal fracture. An analysis showed it to contain,

Analysis of hydraulic limestone.

Carbonate of lime	70·53
Carbonate of magnesia	6·77
Carbonate of iron	3·02
Alumina	3·85
Silica	15·95
	100·12

The dark colour is due to the presence of carbonaceous matter. This, however, burns away during calcination, leaving a buff-coloured lime from which gelatinous silica separates on treatment with hydrochloric acid. It will be seen that the limestone does not differ essentially from many which are elsewhere employed for the manufacture of hydraulic lime. Mr. Garriepie, however, states that he has erected a kiln and burned some of the stone, and that it exhibits no hydraulic properties whatever. But specimens sent to Montreal show that several kinds of limestone have been burned together, and it is more than likely that those in charge of the burning have been persons without any experience whatever in the manufacture of hydraulic lime.

Dolomite.

A specimen of a hard rusty-weathering dolomite was also brought to the museum by Andrew Bell, Esq., C. E. It came from the township of Rigaud, near to the Rivière a la Graisse, and also to the boundary line between Quebec and Ontario, and is probably from the Calciferous formation. Its analysis gave,

Carbonate of lime	39·91
Carbonate of magnesia	32·85
Soluble alumina and ferric oxide	3·56
Insoluble matter	23·54
	99·86

The insoluble portion contained,

Silica	76·34
Alumina and ferric oxide	14·74
Lime	1·02
Magnesia	7·99
	100·09

There can be little doubt that this rock would yield hydraulic lime, the quality of which could, however, only be determined by experiment.

Marl

In the Report of the Survey for 1871-72, Professor Bell mentions (p. 106) an "indurated, pink-colored calcareous marl," which occurs in horizontal beds on the Pikitigouching River. A specimen which he requested me to analyze was collected by his assistant, Mr. Lount. It contained,

Silica	39·87
Alumina and ferric oxide	9·34
Lime	22·40
Magnesia	6·24
Carbonic acid	23·40
	101·25

The residue left after treatment with hydrocloric acid amounted to 42·84 per cent. of the rock.

I have the honour to be,
Sir,
Your most obedient servant,
B. J. HARRINGTON.

GEOLOGICAL SURVEY OF CANADA,
MONTREAL, 1875.

CHEMICAL CONTRIBUTIONS

TO THE

GEOLOGY OF CANADA,

BY

CHRISTIAN HOFFMANN,

ADDRESSED TO

A. R. C. SELWYN, Esq., F.R.S., F.G.S.,

DIRECTOR OF THE GEOLOGICAL SURVEY OF CANADA.

SIR,—In addition to those analyses which have been inserted in the text of accompanying reports, the following have been selected as possessing sufficient interest to warrant their being recorded.

A. Rocks and Minerals.

1. *Banded Limestone from Ramsay and Lanark.*

The analysis of this limestone will be found in Mr. H. Vennor's Report, page 141. As this rock is of considerable interest, a more detailed description than that inserted with the analysis is given here.

Description of limestone.

The rock has throughout a rather coarsely crystalline-granular structure, the grains of which are not very coherent, and is made up of alternate layers of a white and a light bluish-grey color, in consequence presenting a banded appearance. These bands are sharply defined; they vary in thickness and arrangement, are not always parallel to each other, or perfectly straight, but often corrugated; also frequently thinning out into each other. The fracture of the rock is in general uneven, at the juncture of the bluish-grey bands with the white, however, it may be said to be very clean. The whole rock, white and bluish-grey bands indifferently, weathers a light brown. The white bands consist of a magnesian limestone which has a vitreous lustre, and is subtranslucent. Through it are disseminated very small grains of glassy quartz, and equally small crystals of tremolite, the whole amounting to 0·896 per cent of these layers. It is worthy of note that in this rock specimen none of the white bands were found to contain a single crystal of tremolite which could be said to be distinctly visible, as it will be observed further on was the case with the bluish-grey layers, which not only contained a far larger proportion of this mineral, but the crystals not unfrequently exceeded half an inch in length.

The bluish-grey bands consist of a dolomitic limestone, subtranslucent, and having a vitreous lustre. The color would appear to be due to the presence of microscopic scales of graphite, which does not, however, amount to more than 0·156 per cent of the bands in question. It is mostly disseminated through, and, to the naked eye, undiscernable crystals of tremolite, which are pretty evenly dispersed throughout these colored bands, which also contain small grains of glassy quartz. In addition to the small crystals of tremolite just alluded to, and which, with the grains of quartz, amount to 1·256 per cent of these colored layers, these bands are traversed by thin columnar crystals of light-grey colored tremolite, which occur parallel to the plane of deposition. In the specimen of rock examined, some of these crystals measured three-quarters of an inch in length; they admitted of being readily detached from their matrix, and were found to amount to 1·027 per cent of these bands.

2. *Kaolinite from Acton.*

Of the precise mode of occurrence of this mineral in this locality nothing very definite is known. The sender, Mr. John Stewart, of Actonvale, stated that he procured it from the twenty-fifth lot of the fifth range of Acton, where it occurs lining cavities in the rock.

Analysis of kaolinite.

It is composed of minute pearly scales of a yellowish-white color. In the freshly collected state it is unctuous and plastic. Specific gravity. 2.577.

The mineral dried at 100° C. gave:—

Silica	44·604
Alumina	39·145
Ferric oxide	1·035
Magnesia	·213
Lime	·390

Soda	·270
Potash	·196
Water	14·240
	100·093

Oxygen ratio for R_2O_3, SiO_2, $HO = 3 : 4 : 2$

3. *Mineral from Elizabethtown, near Brockville.*

This is the mineral referred to by Dr. Harrington in his report, page 305, as "resembling hisingerite in appearance."

Characters of mineral from Elizabethtown.

It has a hardness of nearly 4. Specific gravity 2.990; structure, amorphous, compact. In some places brilliant faces, showing striations; color, black; lustre, earthy; fracture, subconchoidal; streak, light-green. Before the blow-pipe fuses a little below 2, affording a magnetic globule. Decomposed (after standing some time) by dilute hydrochloric, sulphuric, and nitric acids, even in the cold, their relative action being in order named. Readily decomposed by cold concentrated hydrochloric acid with separation (as in above instances) of silica, as a non-gelatinous powder.

The powdered mineral suffers a decomposition at 100° C.—a portion of the ferrous oxide passing over into the condition of ferric oxide. The analysis was conducted upon the undried mineral. The hygroscopic moisture was determined by drying in vacuo over sulphuric acid.

Analysis.

Silica	29·069
Alumina	12·121
Ferrous oxide	30·782
Ferric oxide	8·311
Manganous oxide	·099
Lime	·364
Magnesia	7·279
Water, combined	10·731
" hygroscopic	1·637
	100·393

Oxygen ratio for RO, R_2O_3, SiO_2, $HO = 1 : 1 : 2 : 1$

4. *Feldspar* (*Labradorite*) *of a Diorite from North Sherbrooke, Lot* 16, *Concession* 3.

This is a coarse-grained diorite consisting of dark olive-green hornblende and a white feldspar, the latter translucent, except on weathered portions, when it becomes opaque white; lustre vitreous on the cleavage surfaces, some of which display fine parallel striæ. Specific gravity 2.697. The rock contained no quartz, but small quantities of both a light and dark colored mica.

Analysis of labradorite.

The feldspar freed as far as possible from all foreign admixture, and dried at 100° C., gave:—

Silica	54·186
Alumina	27·508
Ferric oxide	·454
Magnesia	·777
Lime	9·386
Soda	6·039
Potash	1·397
Water	1·121
	100·868

Oxygen ratio for $R\,O$, $R_2\,O_3$, $Si\,O_2 = 1 : 2{\cdot}7 : 6$.

5. PYRITE FROM LONDONDERRY, NOVA SCOTIA.

Analysis of pyrite.

The Mineral dried at 100° C. gave:—

Iron	45·193
Nickel	·144
Cobalt	·813
Copper	Trace.
Sulphur	52·434
Silica	·523
Alumina	·513
Ferrous oxide	·179
Lime	·430
Magnesia	·177
	100·406

B.—MINERAL WATERS.

1. *Sulphur Spring—Eastman's Springs, near Ottawa.*

Description of mineral water.

When received this water was perfectly clear; it had a very faint yellowish tinge, which, upon reducing the water to a small bulk by evaporation, deepened into a bright brown. This color would appear to be due to the presence of organic matter. Reaction slightly alkaline. One sample of the water forwarded for examination was found to have a specific gravity of 1002·6. Another of more recent collection, however, and that of which the following is an analysis, had a specific gravity of

1001·95. Owing to the very small quantity of the water available for analysis, it was not possible to determine the amounts of lithia, phosphoric acid, boracic acid or iodine, or to determine the nature of the organic matter. The presence of bromine requires confirmation. Baryta is present, but in such small quantity as to be undeserving of notice—it cannot amount to more than a mere trace. The amount of carbonic acid found sufficed within 0·0117 to form bicarbonates with the balance of the soda, the lime, magnesia, and iron. It is, however, highly probable that a portion of the soda thus calculated is really combined with iodine and boracic acid. This spring would appear to belong to the same class of waters as those of Caledonia, Varennes, and Fitzroy, which were examined by Dr. T. S. Hunt. *Vide* Geology of Canada, 1863, page 531.

Analysis.

The water contains in 1,000 parts:—

Potassa	·0271
Soda	1·4533
Lithia	Undet.
Lime	·0190
Magnesia	·0468
Alumina	Traces.
Protoxide of iron	·0027
Sulphuric acid	·0015
Phosphoric acid	Undet.
Boracic acid	Undet.
Carbonic acid	·5625
Silica	·0124
Chlorine	1·3282
Iodine	Undet.
Water in bicarbonates (calculated)	·1175
Organic matter	·0917
	3·6627.
Less oxygen equivalent to the chlorine	0·2996
Total,	3·3631

Probable state of combination of acids and bases.

The foregoing acids and bases are probably combined in the water as follows:—

Chloride of sodium	2·1584
" potassium	·0400
Sulphate of potash	·0033
Bicarbonate of soda	·8365
" lime	·0549

Bicarbonate of magnesia	·1709
" iron	·0066
Alumina	Traces.
Silica	·0124
Organic matter	·0917
Lithia Phosphoric acid Boracic acid Iodine	Undet.
	3·3747
Less carbonic acid actually found	·0117
In 1000 parts of water	3·3630

Specific gravity 1001·95.

2. *Saline Spring—Eastman's Springs.*

Description of mineral water. The quantity of water forwarded was far too small to admit of a complete analysis. The principal constituents, however, have been estimated, leaving the lithia, baryta, strontia, bromine, iodine, and phoshphoric acid undetermined. The first sample of this water received had a specific gravity of 1020. A subsequent collection, and that of which the following is an analysis, had a specific gravity of 1019·44. When received it had a brownish-yellow color and was turbid; after standing for some time it became perfectly clear and colourless; the deposited matter consisted mainly of ferric hydrate, which had, doubtless, at one time existed in the water as ferrous carbonate. The whole of the sodium has been calculated as chloride, a portion of the same, however, is present as bromide and iodide. Again it is inferred that a portion of the carbonic acid represented as in combination with lime, is really present in combination with a trifling portion of the magnesia and some of the undetermined bases. This water would appear to belong to the same class as those of Ancaster, Whitby, and Hallowell, (it has, however, a lesser density) which were analyzed and reported upon by Dr. T. S. Hunt. *Vide* Geology of Canada, 1863, page 547.

Analysis. The water contained in 1,000 parts:—

Potassa	.0996
Soda	10.0654
Lithia	Undet.
Baryta	"
Strontia	"
Lime	2.1744

Magnesia	·8020
Alumina	·0022
Ferrous oxide	·0049
Ferric oxide	·031
Copper	Minute trace
Chlorine	15·6938
Bromine	Undet.
Iodine	"
Sulphuric acid	·0117
Phosphoric acid	Undet.
Carbonic acid	·1023
Silica	·0090

The foregoing acids and bases are probably combined in the water as lows:—

State of combination of acids and bases.

Chloride of sodium	18·9812
" potassium	·1577
" calcium	4·1692
" magnesium	1·9031
Sulphate of lime	·0199
Bicarbonate of lime	·1773
" iron	·0121
Alumina	·0022
Silica	·0090
Copper	Minute trace.
Ferric oxide	·0311
Lithia	Undet.
Baryta	
Strontia	
Bromine	
Iodine	
Phosphoric acid	
In 1000 parts of water	25·4628

Specific gravity 1019·44.

I have the honour to be,

Sir,

Your most obedient servant,

CHRISTIAN HOFFMANN

GEOLOGICAL SURVEY OF CANADA,
MONTREAL, *May*, 1875.

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